OIL SHALE TRACT C-B

SUPPLEMENTAL MATERIAL TO DETAILED DEVELOPMENT PLAN MODIFICATIONS

SUBMITTED BY

ASHLAND OIL, INC.
OCCIDENTAL OIL SHALE

7/21/77 LS

14.0

C·b Shale Oil Venture

2372 G Road – P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

RECEIVED

APR 18 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

April 18, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
Mesa Federal Savings Building
131 North Sixth Street, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

In response to your request, I am sending a breakdown of manpower by skill for the C-b development. These numbers represent the permanent work force.

Very truly yours,
C-b SHALE OIL VENTURE

R. E. Thomason

R. E. Thomason
Manager, Leasehold Development

RET:rp

enc.

cc: R. A. Loucks
R. J. Fernandes
J. J. Hill

C-b SHALE OIL VENTURE

Manpower

RECEIVED
APR 1 8 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

MINING OPERATION

	Classification	Number Required
Production Staff	Mine Superintendent	1
	Assistant Mine Superintendent	1
	General Mine Foreman	1
	Shift Foreman	16
	Chief Clerk	1
	Mine Clerk	2
	Mine Warehouseman	1
	Warehouse Clerk	8
	Conveyor Foreman (Surface)	4
	Conveyor Foreman (Underground)	4
Technical Staff	Chief Mine Engineer	1
	Mine Engineer	3
	Rock Mechanics Engineer	1
	Assistant Engineer	8
	Ventilation and Safety Engineer	1
	Assistant Ventilation and Safety Engineer	4
	Chief Surveyor	1
	Mine Surveyor	8
	Surveyor Helper	8
	Chief Geologist	1
	Geologist	2
	Draftsman, Mine	2
	Draftsman, Geology	1
	Engineering Clerk	2
Maintenance Staff	Maintenance Superintendent	1
	Mechanic Foreman	8
	Electrical Foreman	4
	Maintenance Clerk	4
Direct Mine Labor	Driller	132
	Driller Helper	132
	LHD Operator	24
	Powderman	32
	Powderman Helper	32
	Powderman (Cap)	32
	Powderman (Cap) Helper	32
	Hoistman	8
	Skip Tender	4
	Crusher/Feeder Operator	20
	Conveyor Operator (Surface)	8
	Conveyor Operator (Underground)	8
	Dozer Operator (Surface)	12

Manpower

MINING OPERATION (Con't.)

	Classification	Number Required
Utility Mine Labor	Rockbolter/Scaler Operator	28
	Rockbolter/Scaler Helper	28
	Fuel Truck Driver	4
	Fuel Truck Helper	4
	Lube Truck Driver	4
	Utility Truck Driver	48
	Dozer Operator (Barricade)	4
	Motor Grader Operator	8
	Mine Labor	100
	Conveyor Patrol (Surface)	24
	Conveyor Patrol (Underground)	40
	Toplander	8
	Cage Tender	4
	Janitor (Dry)	4
Maintenance Labor	Hoist Oiler	8
	Drill Doctor	16
	Mine Mechanic	32
	Mechanics Helper	32
	Mine Electrician	32
	Electrician Helper	32
	Lampman (Dry)	4
	TOTAL	1,039

PROCESS OPERATORS

	Classification	Number Required
	Operations Superintendent	1
	Assistant Superintendent	1
	Chief Supervisor (Underground)	1
	Chief Supervisor (Surface)	1
	Shift Supervisor (Underground)	4
	Shift Supervisor (Surface)	4
	Operations Engineer	2
	Area Engineer	6
	Safety Supervisor	1
	Laboratory Supervisor	1
	Chemist	1
	Laboratory Technician	8
	Chief Clerk	1
	Assistant Clerk	1
	Secretarial/Clerical	10
	Lead Operator	36
	Operator	72
	Construction/Startup Operator	67
	TOTAL	218

Manpower

MAINTENANCE AND UTILITIES

	Classification	Number Required
	Machinist	6
	Electrician	20
	Pipe Fitter	12
	Mechanics - Auto	15
	Sheet Metal	15
	Instrument Tech.	14
	Welder	20
	Tool Crib	8
	Laborers	20
	Mobile Equipment	10
	Bus Driver	45
	Area Maint. Mech.	70
	Boiler Plant Oper.	4
	Warehouseman	12
Foremen	Machine Shop	1
	Electrical	1
	Pipe Fitter	1
	Instrument	1
	Welder	1
	Area Maintenance	1
	Warehouse	1
Ass't. Foremen	Machine Shop	1
	Electrical	1
	Pipe Fitter	2
	Instrument	4
	Welder	1
	Area Maintenance	1
	Warehouse	1
Other	Security Chief	1
	Guards	24
	Instrument Supt.	1
	Instrument Eng.	2
	Clerks	10
	TOTAL	327

GENERAL ADMINISTRATION AND SUPPORT		16
	TOTAL	16
	TOTAL MANPOWER	1,600

MINING PLAN
for
ANCILLARY DEVELOPMENT

Presented by

C-b SHALE OIL VENTURE

ASHLAND COLORADO, INC.

OCCIDENTAL OIL SHALE, INC.

OPERATOR

Job No. 5681-01

June 1977

The Ralph M. Parsons Company
Parsons-Jurden Division

INTRODUCTION

OBJECTIVES

- TRANSLATE OXY'S MODIFIED IN SITU TECHNOLOGY TO HIGH GRADE OIL SHALE WITH THICK SECTION INTO COMMERCIAL OPERATION
- ESTABLISH ENVIRONMENTAL MONITORING PROCEDURES
- OBTAIN OPERATING EXPERIENCE FOR PROCESSING A CLUSTER OF RETORTS
- PROVIDE SITE FOR TRAINING OF MINING AND PROCESSING PERSONNEL
- ATTAIN EARLIEST PRODUCTION TO MEET DUE DILIGENCE REQUIREMENT

Shale Oil Venture
2372 G Road — P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

July 8, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
U.S.G.S. Conservation Division
Mesa Federal Savings & Loan
131 N. 6th, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

The "Mining Plan for Ancillary Development" submitted to you June 16, 1977 omitted page numbers. Pages should be numbered starting with page 1 which begins "THIS COLLECTION OF OUTLINES - - -", and continues numbering through 43 for the last printed page. The Mining Plan as described in this document presents:

- Description of Facilities for Ancillary Development (p. 4)
- Schedules for Development (pp. 5, 6, 7)
- C-b Tract General Arrangement (p. 9)
- Mine Support Facilities at Surface (p. 10)
- Ancillary Process Facilities (p. 11)
- Shaft Location (p. 12)
- Head Frame (p. 13)
- Ventilation Escape Shaft General Arrangement (p. 14)
- Mine Level Development (pp. 15, 16, 17, 18)
- Ventilation Circuits During Development (pp. 22, 23, 24)
- Ventilation Circuits During Retorting (pp. 25, 26)

In addition, four drawings were submitted separately under confidential agreement and provide supplemental descriptions of mine/retort development and ventilation.

The following additional dialogue was requested to provide support for the material presented and to reference the appropriate section of the Modification to the DDP to which they apply.

<u>Description of Facilities for Ancillary Development</u>

<u>Surface Facilities:</u>

<u>Head Frame</u> (page 13). An elevation view is presented to describe the 147' high head frame set over the 15' diameter Ventilation Escape Shaft, the hoisting arrangement, power head and control location. This sketch provides additional details for MDDP Section III-D-2.

General Arrangement (page 9). General facilities location on the tract are presented taking into consideration relocations of shafts and reorientation of mine layout that considers the joint set system of the geologic formation. Relocation of the Temporary Gas Shaft also was in consideration of more efficient operation to fit future mining and resource recovery. This sketch modifies MDDP Section III-D-2 and Figures 1-A, III-A, III-B and III-H.

Mine Support Facilities (page 10). The conceptual layout of mine support facilities is described locating: Utility Steam Generation Plant, Change House and Mine Office Building, Maintenance Shop, Warehouse; as they relate to the main Production and Service Shafts. This sketch provides additional information for MDDP Section III-D-2.

Ancillary Process Facilities (page 11). Process facilities are identified and located in relationship to the Ventilation Escape Shaft and Temporary Gas Shaft. This sketch provides additional information for MDDP Section III-D-2.

Shaft Location (page 12)

In general, shafts have been relocated to conform to the joint, set system of the formation and to improve future operations efficiency and resource recovery. The Temporary Gas Shaft has been relocated to approximately 200 feet southwest of the Ventilation Escape Shaft on the common centerline (72° W of N). This information and sketch modifies MDDP Section III-C-4, III-D-2, III-D-3.a, Figure III-A, III-B.

Shaft Pillar Dimensions are shown on page 12 and described with 500' radius for the Ventilation Escape Shaft and Temporary Gas Shaft complex, and 1275' radius for the Production and Service Shaft complex. These dimensions reflect the ancillary criteria which may be later modified following ground stability data collected during early development. This is additional information provided for MDDP Section III-D-2.

Shaft Size (page 4, 14)

Shaft sizes have been modified to reflect refinements in ventilation and equipment requirements. The Ventilation Escape Shaft completion diameter has been increased to 15' and will be sunk by conventional means and lined with concrete. The Temporary Gas Shaft completion diameter has been increased to 10'. This shaft will be drilled. This information and sketch modifies MDDP Section III-C-4.b & c and III-D-2, III-D-3.a.

Ventilation Escape Shaft (page 14). The general arrangement is described in horizontal cross section showing: loading pocket, ventilation ducts, cage, skip, manway, and services location. This sketch provides additional information for MDDP Section III-C-4.b and III-D-2.

Mining

Drift Size (page 4). Air level drifts are sized 30' wide and 20' high. Production level drifts are sized 30' high and 20' wide. This provides additional information for MDDP Section III-D-3.a.

Mine Plan (page 4). The mine plan is presented in two primary concepts (VFFR, HFFR) for retort void formation.

Mine Level Layout Development: Each system (VFFR, HFFR) is described (pages 15, 16, 17, 18) and in four confidential sketches submitted separately. These sketches provide additional information for MDDP Section III-D-3.a.1.

Ventilation Circuits During Development (pages 22, 23, 24). Sketches of five phases of shaft and mine development are presented with ventilation circuitry noted by arrows. These sketches provide additional information for MDDP Section III-D-3.a and replace Figure III-C & D.

Ventilation Circuits During Retorting (pages 25, 26). Ventilation as it relates to the two retort development systems is described and circuitry noted by arrows. In response to discussions held at the MESA, CBM briefing held June 21, 1977 a refinement will be made in the upper air level connecting the stub drift shown to the drift leading to the main shaft area. Subsequent design and sketches will reflect this change. These sketches provide additional information for MDDP Section III-D-3.a and replace Figure III-E.

Schedules for Ancillary Facility Development (pages 5, 6, 7)

These schedules present dynamic refinements and as a result some changes to the original schedule presented in Figure 1-B of the MDDP. As a dynamic vehicle the development schedule will be continually revised to reflect a current position. The schedules (pages 5, 6, 7) therefore replace that part of MDDP Figure 1-B to which they apply.

Very truly yours,

C-b SHALE OIL VENTURE

R.E. Thomason

R. E. Thomason
Manager, Leasehold Development

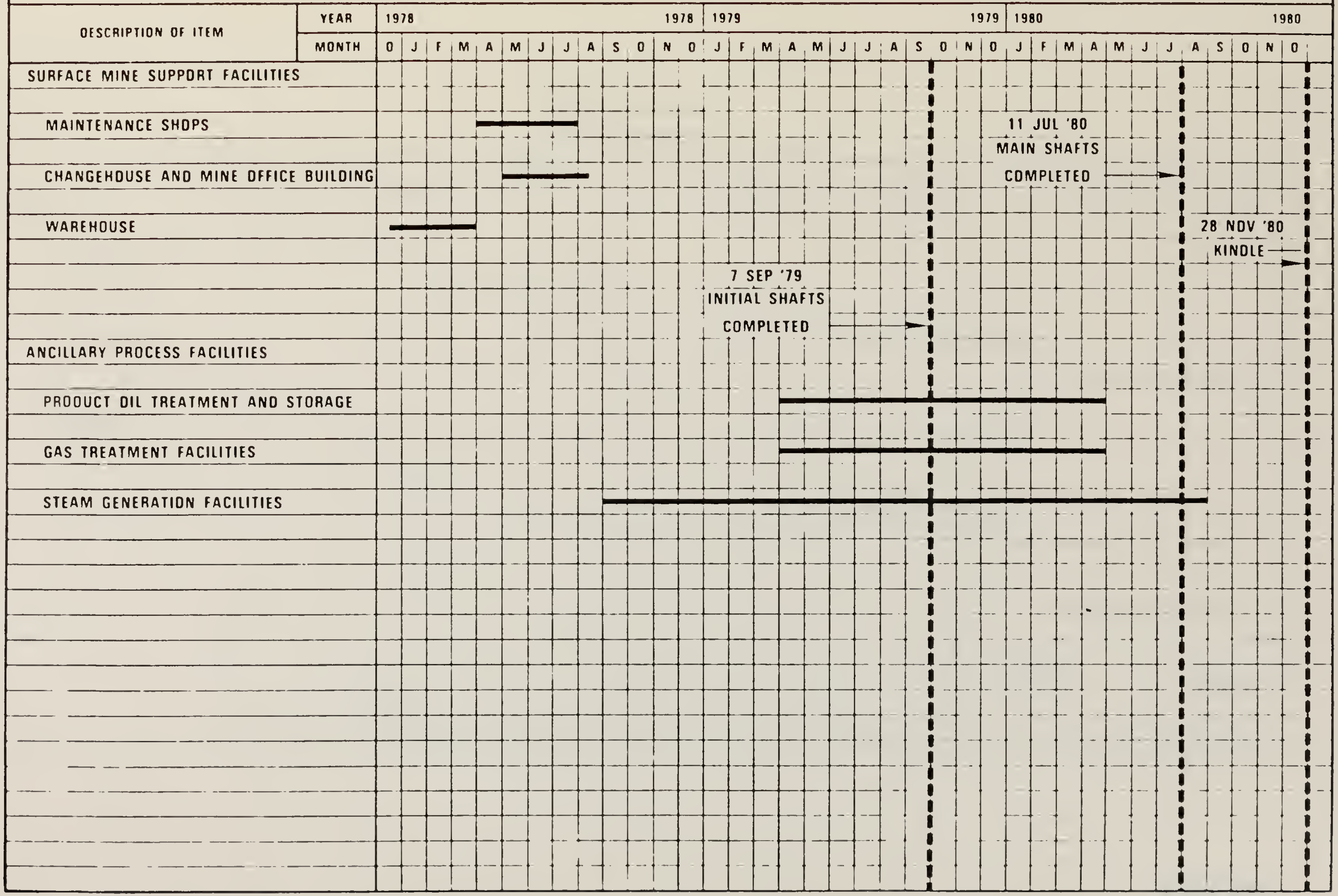
RET:pmr

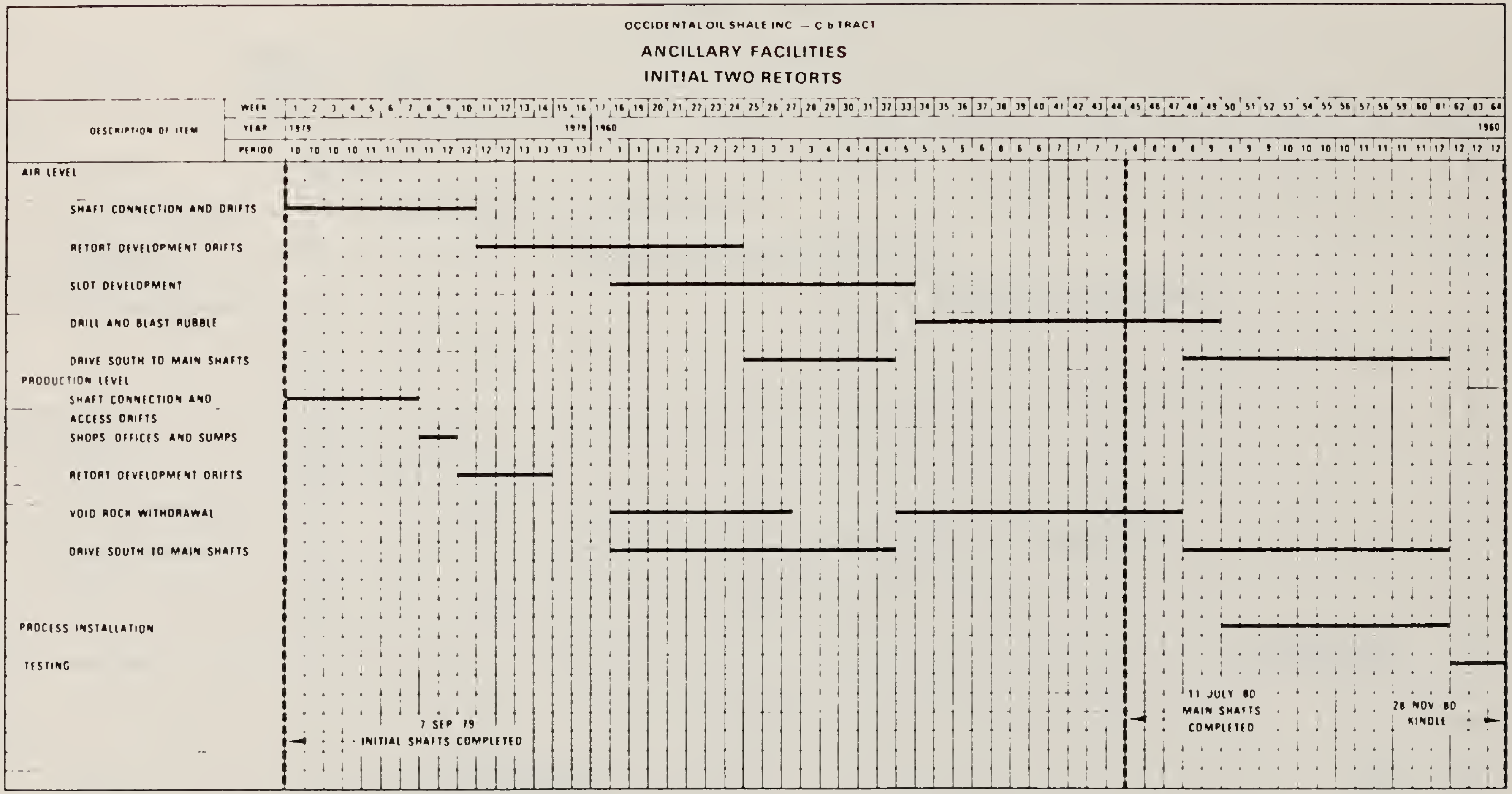
cc: J. J. Hill
R. A. Loucks
R. J. Fernandes

OCCIDENTAL OIL SHALE INC., C-b TRACT

ANCILLARY FACILITIES

SURFACE PROCESS AND MINE SUPPORT FACILITIES

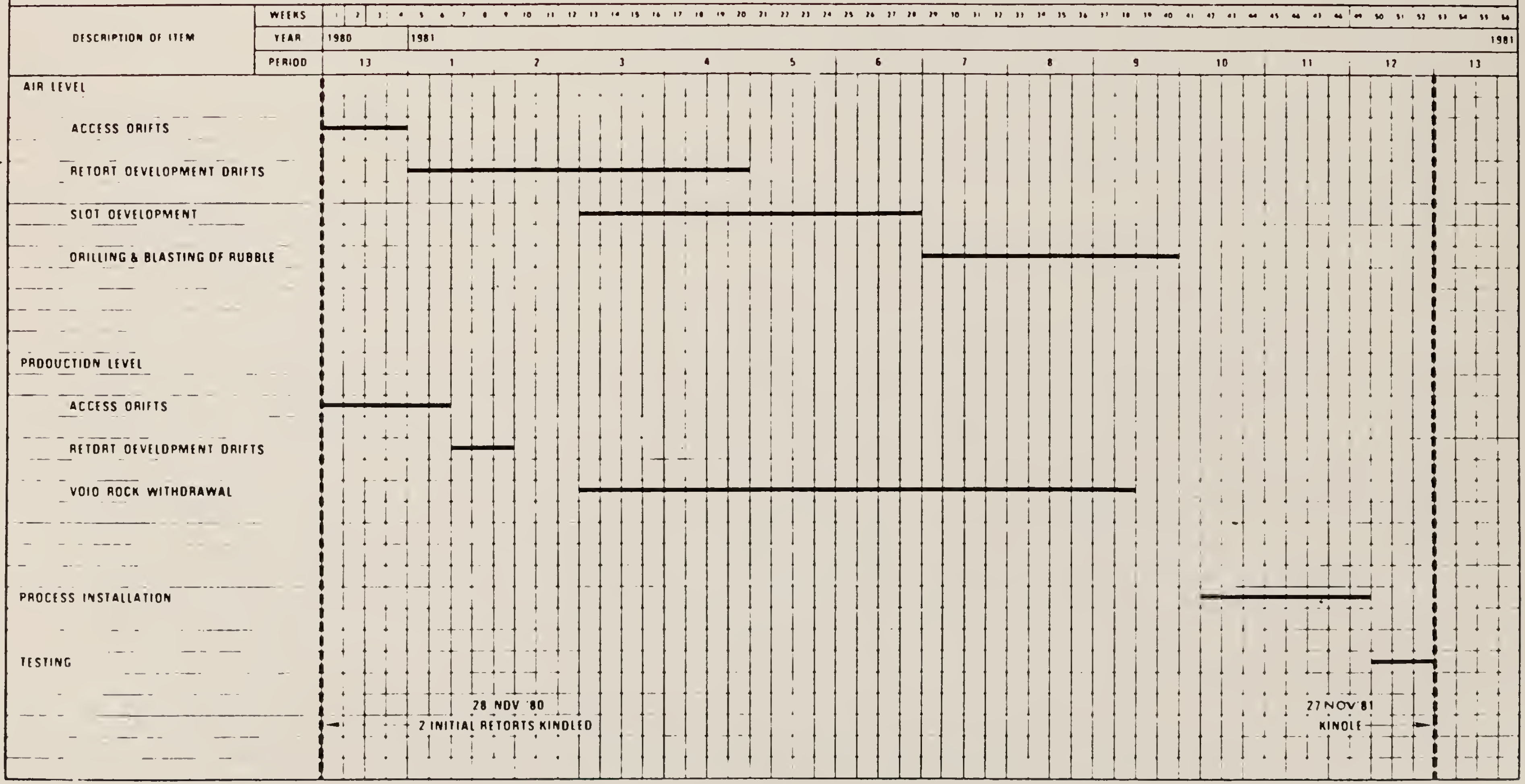



OCCIDENTAL OIL SHALE INC — C b TRACT
ANCILLARY FACILITIES
INITIAL TWO RETORTS
DESCRIPTION OF ITEM
WEEK
YEAR
PERIOD
1979
1980
AIR LEVEL
SHAFT CONNECTION AND DRIFTS
RETORT DEVELOPMENT DRIFTS
SLOT DEVELOPMENT
DRILL AND BLAST RUBBLE
DRIVE SOUTH TO MAIN SHAFTS
PRODUCTION LEVEL
SHAFT CONNECTION AND ACCESS DRIFTS
SHOPS OFFICES AND SUMPS
RETORT DEVELOPMENT DRIFTS
VOID ROCK WITHDRAWAL
DRIVE SOUTH TO MAIN SHAFTS
PROCESS INSTALLATION
TESTING
7 SEP 79
INITIAL SHAFTS COMPLETED
11 JULY 80
MAIN SHAFTS COMPLETED
28 NOV 80
KINDLE

RMP

OCCIDENTAL OIL SHALE INC., C b TRACT

ANCILLARY FACILITIES
FOUR TEST RETORTS



RMP

DESCRIPTION OF FACILITIES FOR ANCILLARY DEVELOPMENT

SURFACE FACILITIES

- HEADFRAME ON 15' DIA. VENTILATION/ESCAPE SHAFT–147' HIGH
- UTILITY STEAM GENERATION
- CHANGE HOUSE & MINE OFFICE BUILDING
- MAINTENANCE SHOP
- WAREHOUSE
- PROCESS GAS TREATING

SHAFTS

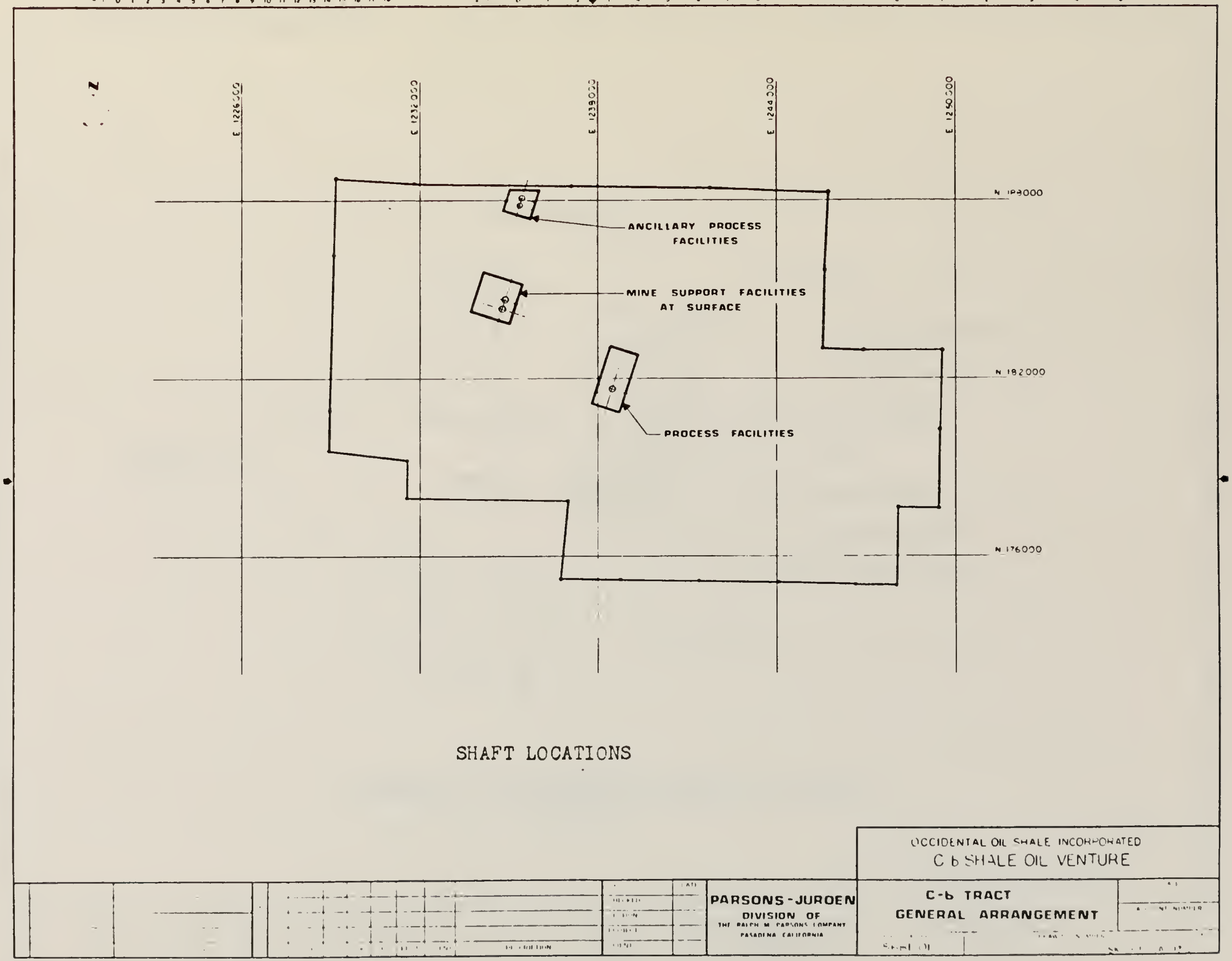
- 15' DIA. VENTILATION/ESCAPE SHAFT - 1700' DEEP (APPROX.)
- 10' DIA. TEMPORARY GAS SHAFT - 1700' DEEP (APPROX.)

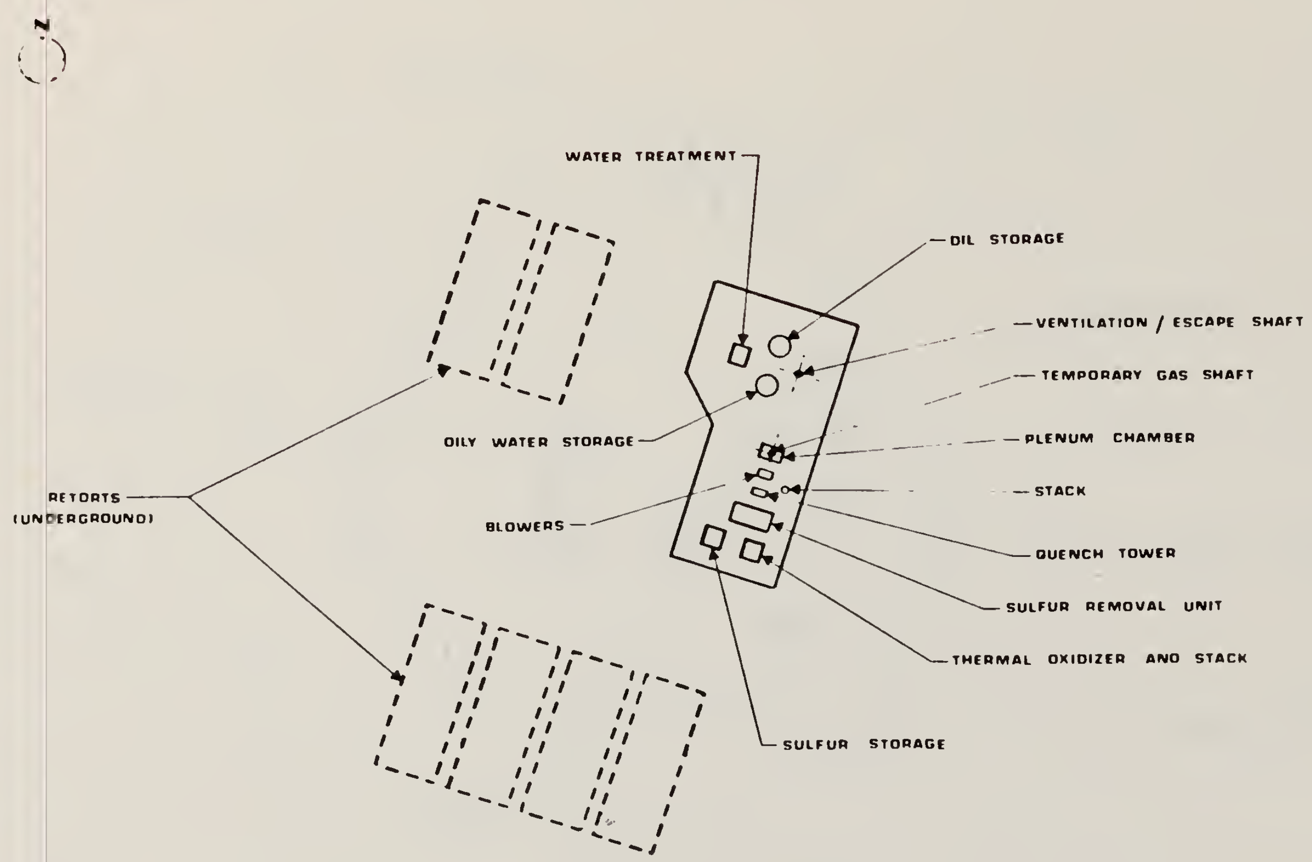
MINING

- AIR LEVEL DRIFT - 30' WIDE X 20' HIGH
- PRODUCTION LEVEL DRIFT - 30' WIDE X 20' HIGH

RETORTS

- 2 RETORTS - 150' X 405' X 290' HIGH - OPERATED TOGETHER
- 4 RETORTS - " " " " - OPERATED AS A CLUSTER


E 1226000
E 1232000
E 1238000
E 1244000
E 1250000
N 188000
N 182000
N 176000
ANCILLARY PROCESS FACILITIES
MINE SUPPORT FACILITIES AT SURFACE
PROCESS FACILITIES
SHAFT LOCATIONS
OCCIDENTAL OIL SHALE INCORPORATED
C b SHALE OIL VENTURE
PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
PASADENA CALIFORNIA
C-b TRACT
GENERAL ARRANGEMENT

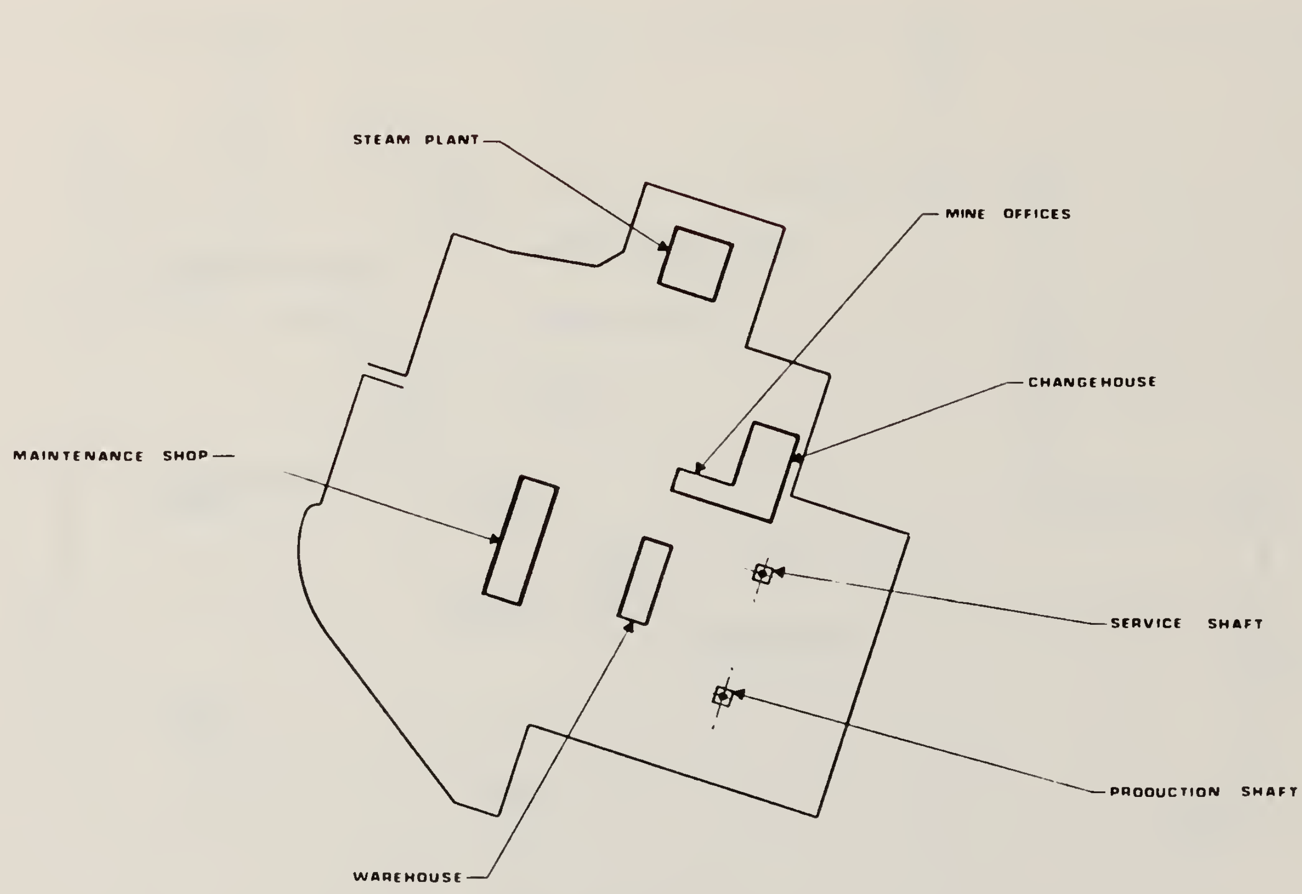


ANCILLARY FACILITIES WITH RESPECT TO INITIAL RETORTS

OCCIDENTAL OIL SHALE INCORPORATED
C-b SHALE OIL VENTURE

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
PASADENA CALIFORNIA

ANCILLARY PROCESS FACILITIES



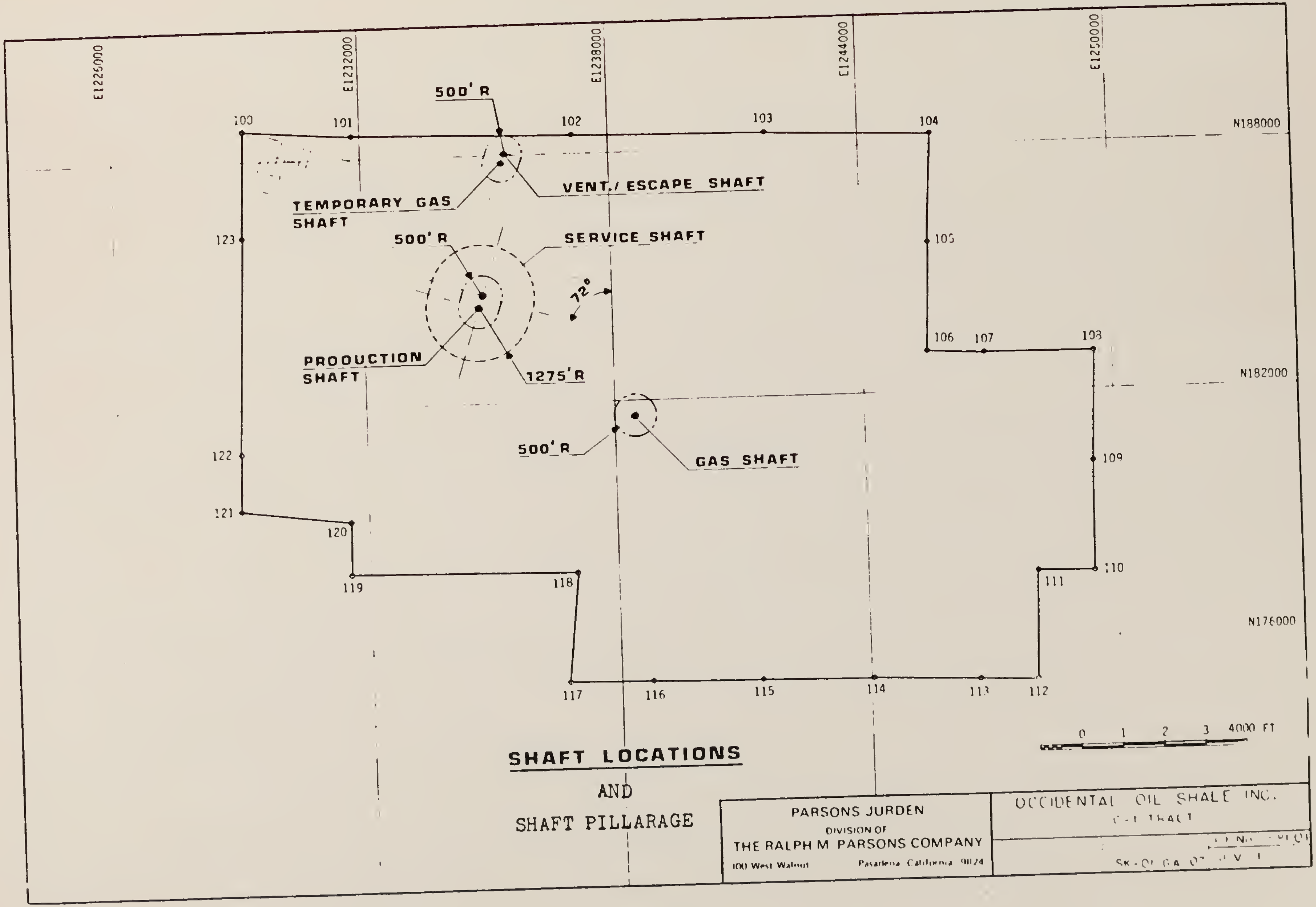
COMMERCIAL FACILITIES WITH RESPECT TO
MAIN PRODUCTION SHAFTS

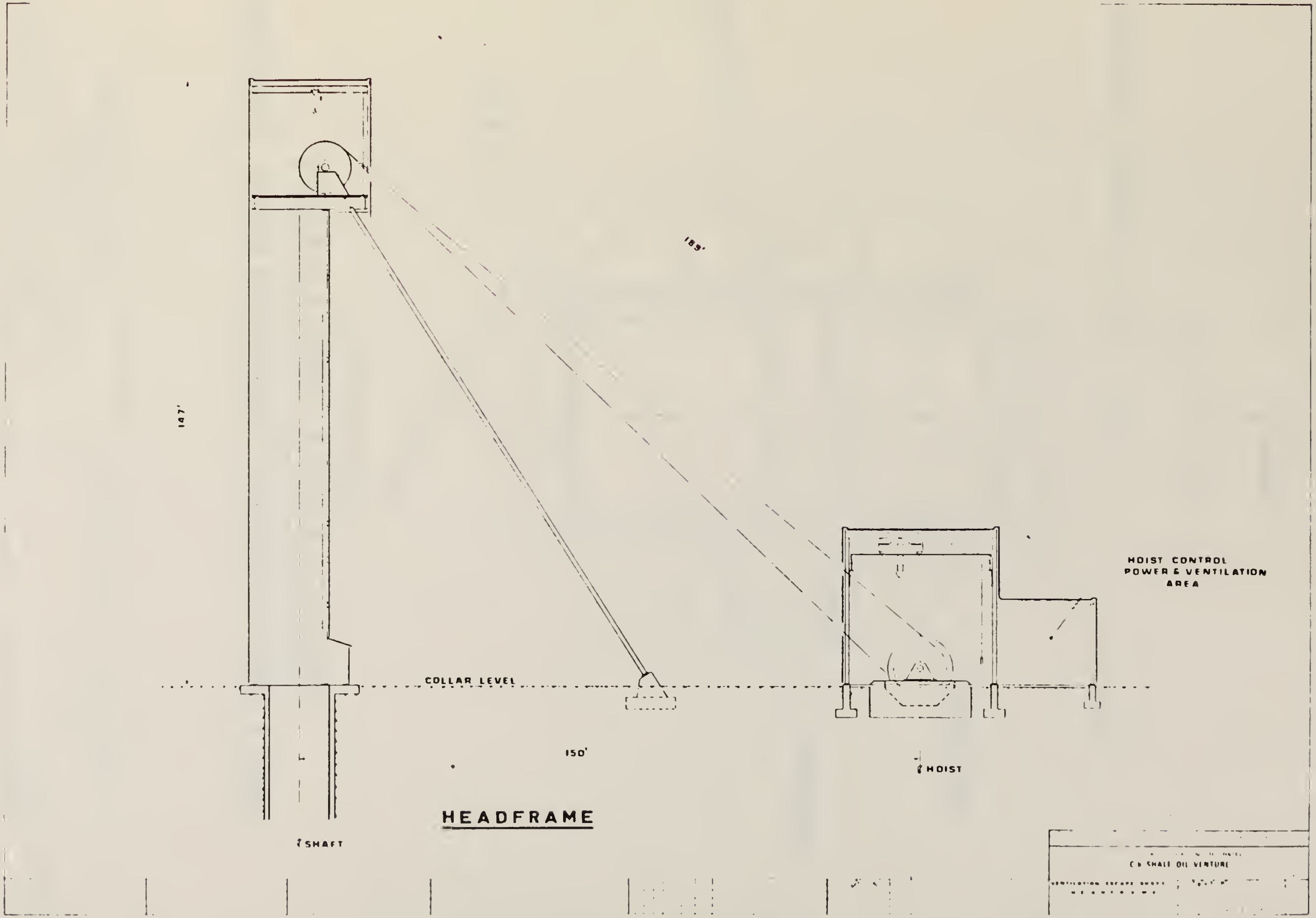
OCCIDENTAL OIL SHALE INCORPORATED
C-b SHALE OIL VENTURE

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
PASADENA CALIFORNIA

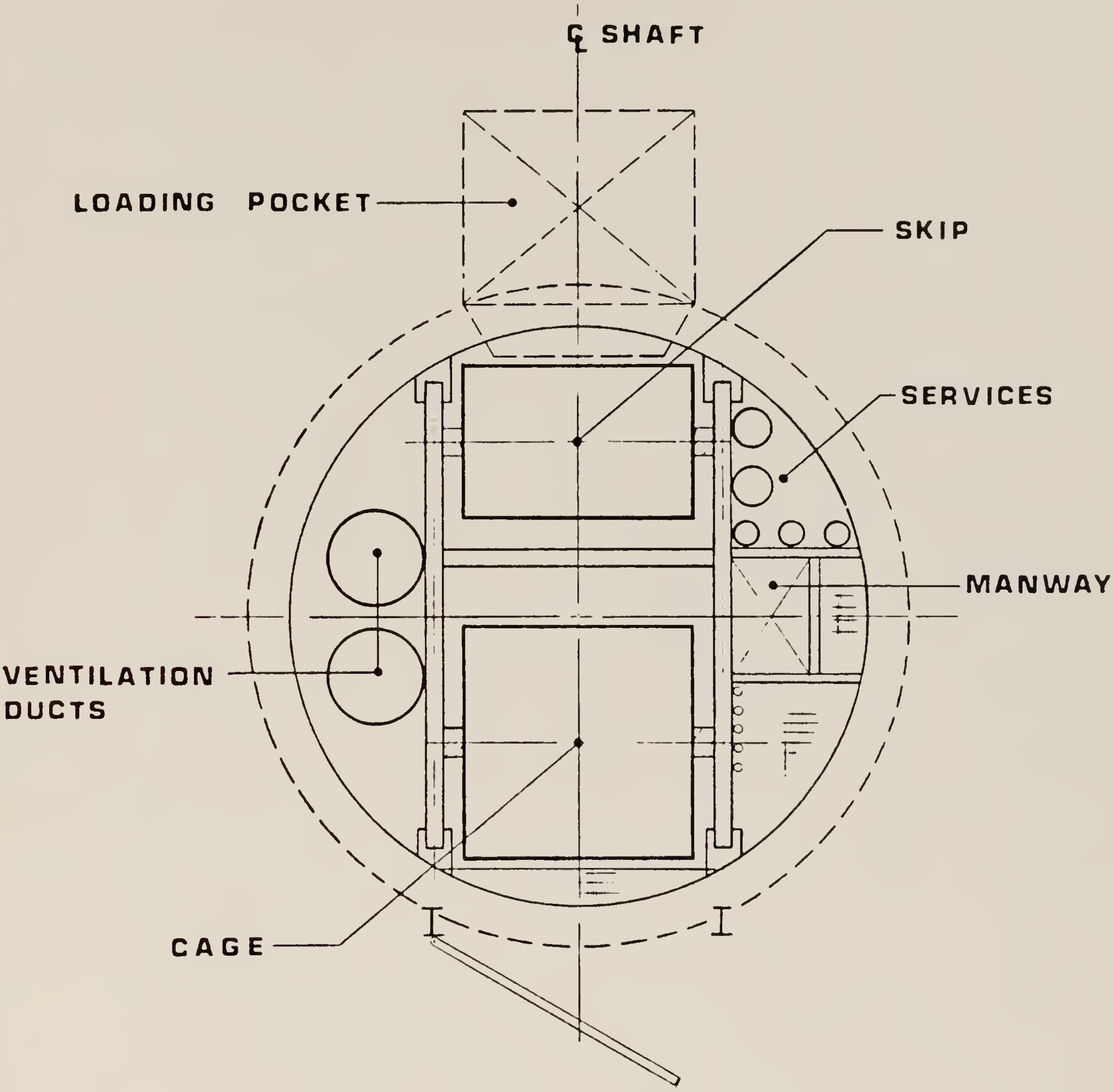
MINE SUPPORT
FACILITIES
AT SURFACE

566101


E1226000
E1232000
E1238000
E1244000
E1250000
N188000
N182000
N176000
500' R
VENT./ ESCAPE SHAFT
TEMPORARY GAS SHAFT
SERVICE SHAFT
500' R
72°
PRODUCTION SHAFT
1275' R
500' R
GAS SHAFT
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
0 1 2 3 4000 FT
SHAFT LOCATIONS
AND
SHAFT PILLARAGE
PARSONS JURDEN
DIVISION OF
THE RALPH M PARSONS COMPANY
100 West Walnut
Pasadena California 91124
OCCIDENTAL OIL SHALE INC.


147'
189'
COLLAR LEVEL
150'
HOIST CONTROL
POWER & VENTILATION
AREA
℄ HOIST
℄ SHAFT
C b SHALE OIL VENTURE

HEADFRAME

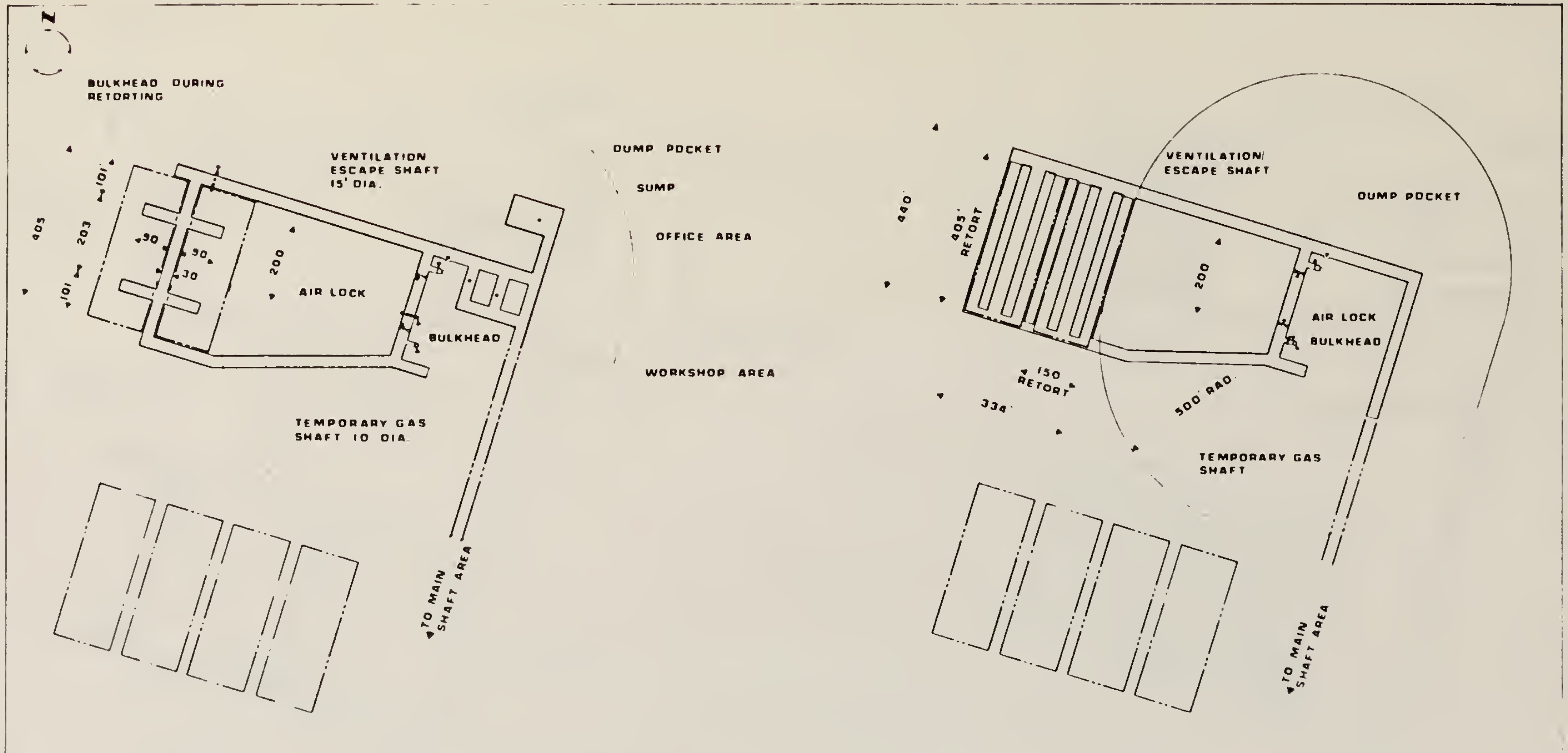


ANCILLARY PHASE

VENTILATION/ESCAPE SHAFT

GENERAL ARRANGEMENT-PRODUCTION LEVEL

PARSONS-JURDEN DIVISION OF THE RALPH M PARSONS COMPANY 100 West Walnut Pasadena California 91124	OCCIDENTAL OIL SHALE INC. C-b TRACT Job No 5681-01 SK-01-GA-08 REV



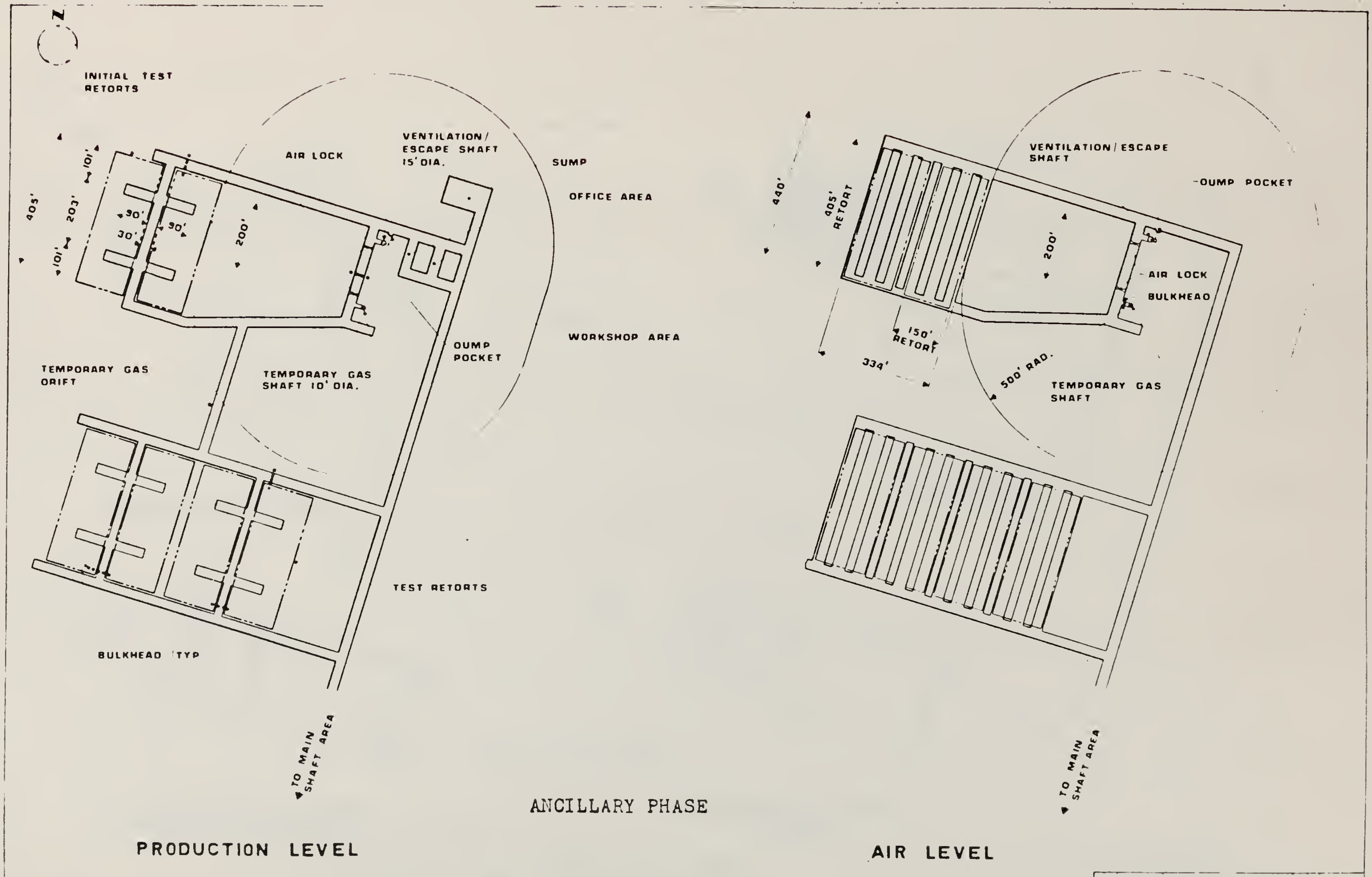
ANCILLARY PHASE

PRODUCTION LEVEL

AIR LEVEL

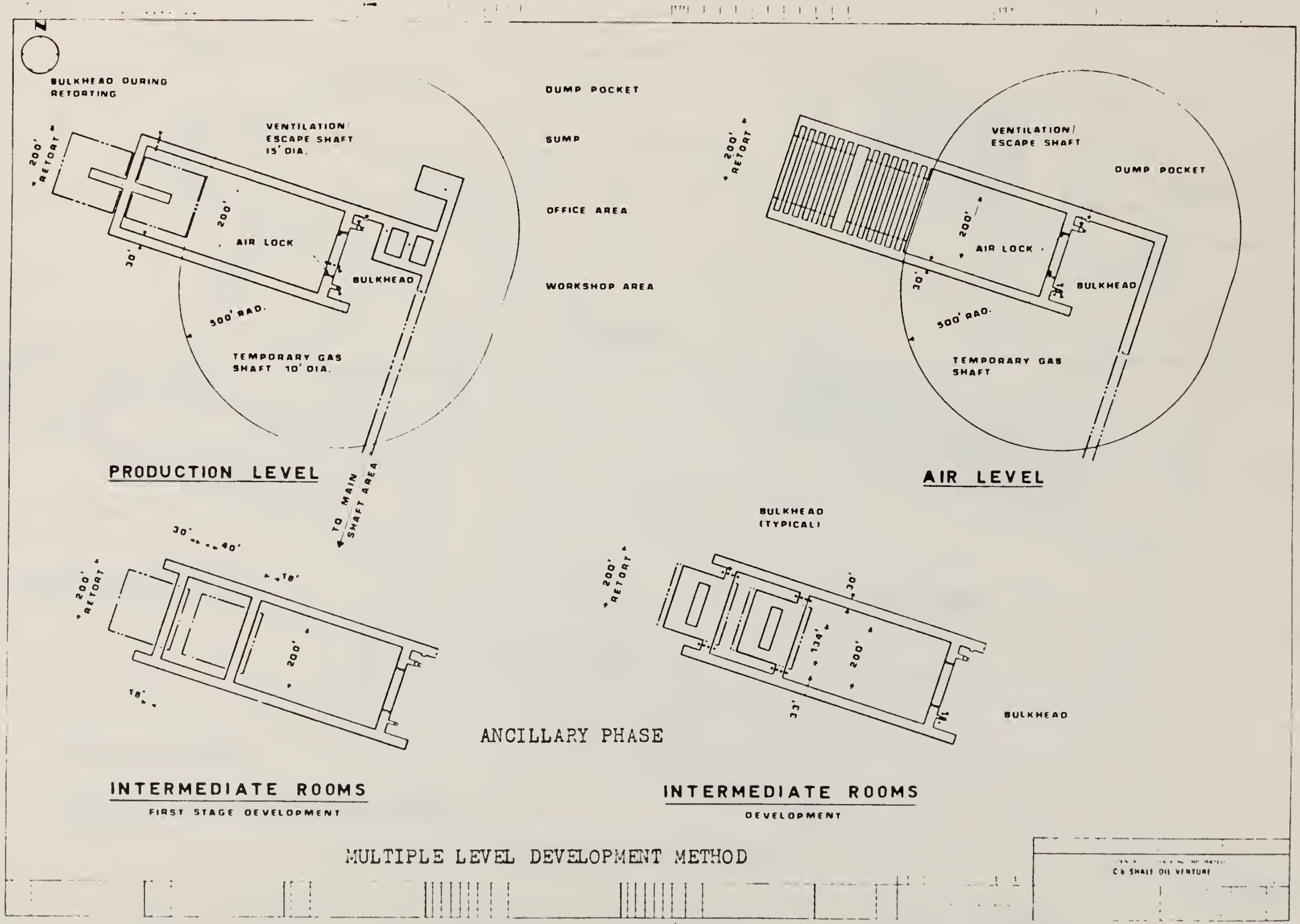
VERTICAL SLOT DEVELOPMENT METHOD

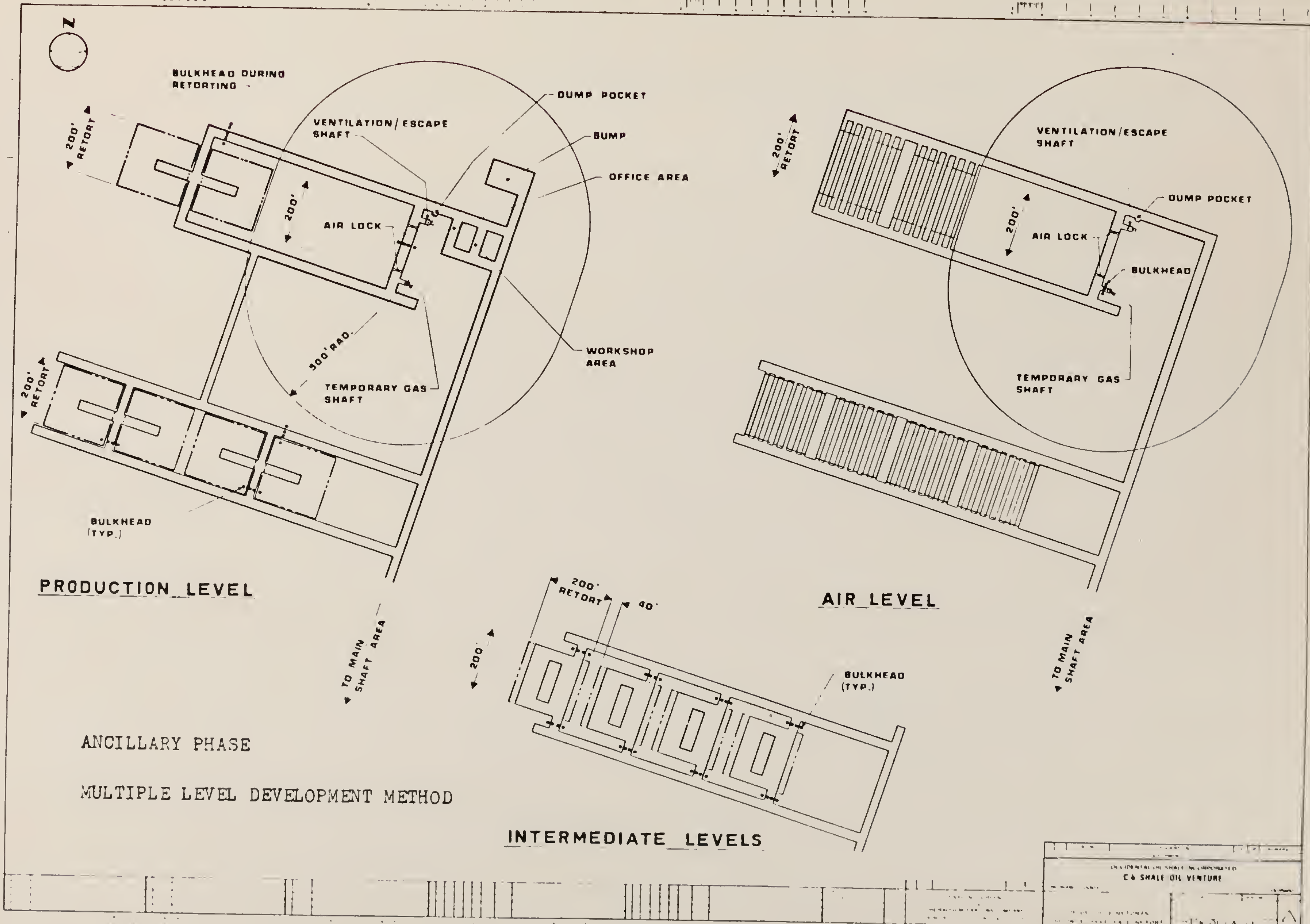
C B SHALE OIL VENTURE



ANCILLARY PHASE

VERTICAL SLOT DEVELOPMENT METHOD

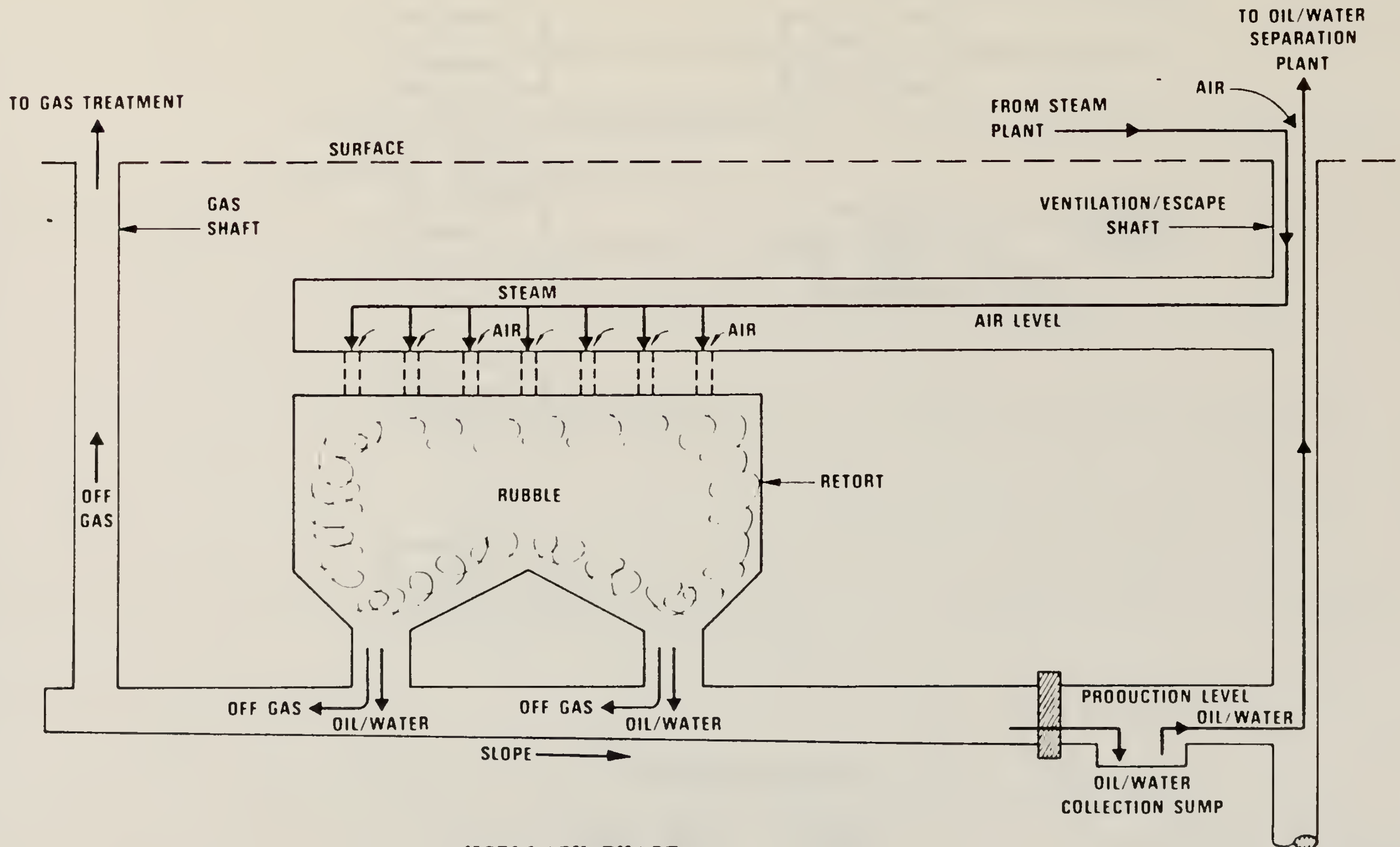

N
BULKHEAD DURING RETORTING
200' RETORT
VENTILATION/ ESCAPE SHAFT 15' DIA.
200'
AIR LOCK
30'
BULKHEAD
500' RAD.
TEMPORARY GAS SHAFT 10' DIA.
PRODUCTION LEVEL
TO MAIN SHAFT AREA
DUMP POCKET
SUMP
OFFICE AREA
WORKSHOP AREA
200' RETORT
VENTILATION/ ESCAPE SHAFT
DUMP POCKET
200'
AIR LOCK
30'
BULKHEAD
500' RAD.
TEMPORARY GAS SHAFT
AIR LEVEL
30'
40'
200' RETORT
18'
200'
18'
BULKHEAD (TYPICAL)
200' RETORT
30'
134'
200'
33'
BULKHEAD
ANCILLARY PHASE
INTERMEDIATE ROOMS
FIRST STAGE DEVELOPMENT
INTERMEDIATE ROOMS
DEVELOPMENT
MULTIPLE LEVEL DEVELOPMENT METHOD
C b SHALE OIL VENTURE



ANCILLARY PHASE

MULTIPLE LEVEL DEVELOPMENT METHOD

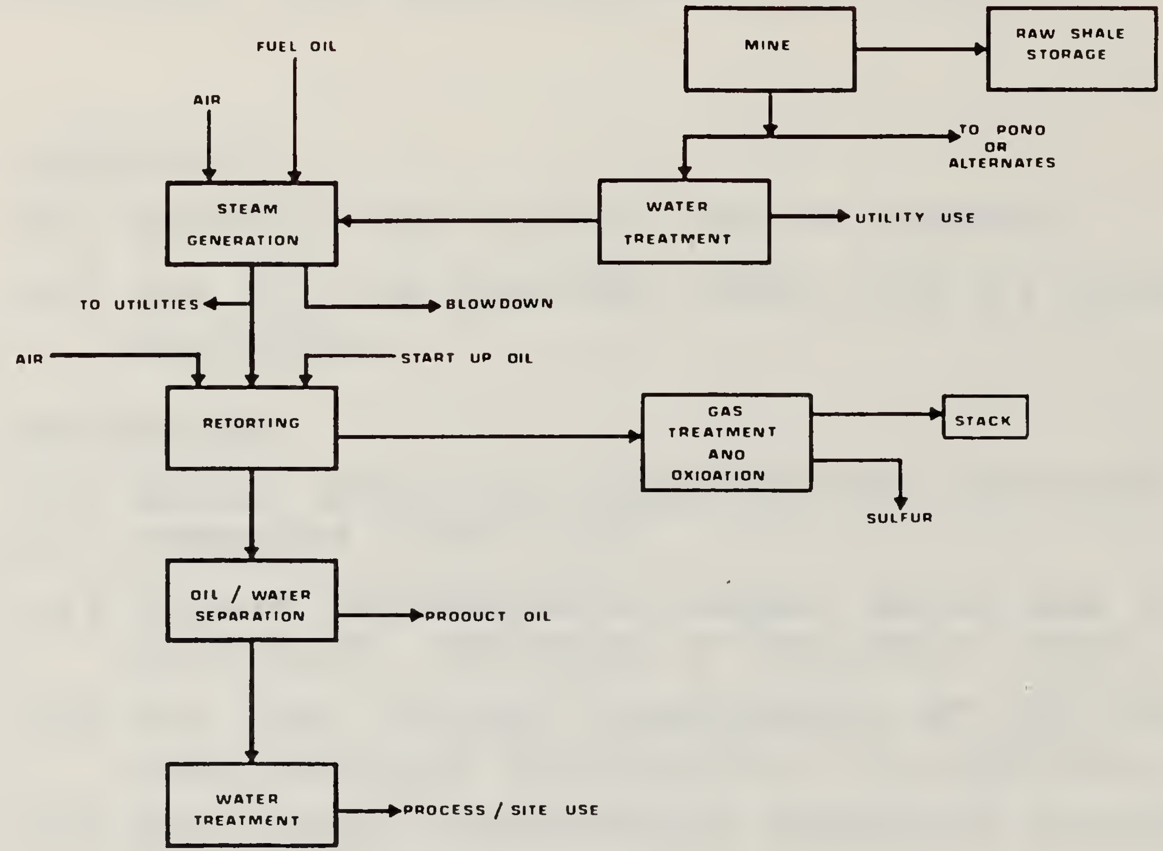
MODIFIED IN SITU RETORTING OF OIL SHALE



ANCILLARY PHASE

RETORT OPERATION

RMP



ANCILLARY PHASE

BLOCK FLOW DIAGRAM

OCCIDENTAL OIL SHALE INCORPORATED
C-b SHALE OIL VENTURE

MODIFIED IN SITU RETORTING
BLOCK FLOW DIAGRAM

5681-01

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

DESCRIPTION OF RETORTING IN BRIEF

(A) START-UP

(1) BURNERS LET DOWN TOP OF RUBBLE.

(2) AIR PULLED THROUGH FROM TOP BY EXHAUST BLOWERS.

(B) RETORTING

(1) WHEN REACTION TEMPERATURE REACHED BURNERS [illegible] TURN OFF.

(2) STEAM INTRODUCED ALONG WITH AIR TO MAINTAIN BURNING AT DESIRED TEMP.

(3) OIL AND WATER CONDENSES AT BOTTOM AND PUMPED SEPARATELY TO SURFACE.

(4) OFF-GASES EXHAUSTED THROUGH BLOWERS TO GAS TREATMENT.

(C) RETORT SHUTDOWN

(1) INLET HOLES AT TOP SHUT OFF, SHUTTING OFF AIR.

(2) RETORT ALLOWED TO COOL DOWN WITH BOTTOM VENT TO GAS SHAFT OPEN.

(3) OFF-GASES PRODUCED AFTER SHUTDOWN FLARED.

ANCILLARY DEVELOPMENT - RETORT OPERATIONS

PURPOSE

This facility will include two commercial sized retorts to be operated simultaneously, followed by four retorts operated as a cluster. These will permit the verification of operational and design parameters, environmental monitoring procedures, and provide operating experience and training of processing personnel. This facility will be incorporated into the full scale operation once the main shafts and other full scale plant units become available.

DESCRIPTION OF IN-SITU RETORTING

In the Modified In-Situ Process retorts are created by mining out only enough shale to provide a void fraction for rubblizing the remaining shale to provide permeability for gas flow during operation.

The processing of the retorts consists of the following steps:

STEP 1
The retort is kindled or "lit-off" at the top using externally fueled burners, which are lowered down from the air level to the top of the rubble pile.

STEP 2
When the temperature at the top is sufficient to sustain the retorting and combustion reaction and the combustion zone is established across the whole cross-section of the retort, the burners are shut off and a regulated mixture of steam and air is drawn through the retort by exhaust blowers on the surface. Residual organic matter is combusted with the air in the feed gas. The hot inert combustion gases flow down through the retort and supply heat to the raw oil shale below. As the shale is heated the organic matter or kerogen decomposes into oil, vapor and hydrocarbon gases which are carried along with the combustion gases. Some residual carbon remains in the shale as char. Steam in the fuel mainly acts as a diluent to the oxygen in the air to control the reaction temperature and also reacts with some of the residual organic material forming additional carbon monoxide and hydrogen which improves the heating value of the product gas. The heating value of the product gas is also enhanced due to the fact that the steam diluent is easily removed from the gas by condensation. The steam diluent also improves efficiency of the energy transfer in the retort due to its higher heat capacity so increasing the oil recovery. As the gas mixture flows down through the retort, it preheats the raw shale and at the same time the oil and some of the water vapor are condensed.

Product gases and liquids leave the bottom of the retort and move to the surface for further processing as product oil, product fuel gas and water. As retorting progresses the combustion and retorting zones move slowly down through the in-situ retort.

STEP 3
When the combustion zone reaches a predetermined distance from the bottom of the retort, the air and steam feeds are stopped thus preventing further advancement of the combustion zone. The retort slowly cools down but continues to produce hydrocarbon gases which are vented into the gas system for use and pollution control treatment. The spent shale remains underground with no need for surface

disposal. Surface process facilities consist only of oil/water separation equipment, exhaust blowers, a sulfur removal unit for treatment of product gas, boilers to produce process steam and water treatment facilities.

ANCILLARY DEVELOPMENT

EMERGENCY PROCEDURES DURING RETORTING

The report, product gas drifts and gas shaft will be operated at negative pressure during normal operation. Back up electrical power will be provided should the normal power supply fail in order to keep the process blowers in operation. The following emergency procedures will be carried out should abnormal conditions develop.

1. BLOWER FAILURE

The retort would continue to vent through the gas drift and gas shaft since gas would continue to be generated inside the retort.

Automatic shut off valves on the air inlets to the top of the retort would be activated, shutting off the air supply and isolating the top of the retort and so stopping combustion. Hydrocarbon gas production from the retort would drop below 20% of normal flow immediately and within two to three days would drop below 10% of normal flow.

2. BLOCKAGE OF RETORT EXIT

In the event of a shut off of the off gases from the bottom of the retort or a surface line failure, the inlet air valves would be shut off by remote control and the retort gases would be vented through the process steam line which is connected to the top of the retort and through a bypass line to the flare stack. All valves on the steam line and bypass line would be remotely controlled.

3. RETORT GAS MONITORING IN DRIFTS

Continuous gas monitoring devices will be placed in the drifts, at bulkheads and other working areas in the vicinity of the retort gases. These will sample the working environment for methane, (LEL), carbon monoxide, oxygen and hydrogen sulphide. In the event of a gas leak, they will alarm both visually and audibly, both locally and in the Control Room.

STEAM HANDLING SYSTEM

The steam for the ancillary phase will be generated by a conventional steam boiler or by an Ameron type thermal sludge steam generator. The thermal sludge unit generates steam by heat exchange to the boiler water from a molten salt which flows through the furnace tubes. Due to the lower tube wall temperatures in the heat exchanger, poor quality water may be used. And so the need for sophisticated boiler feed water treatment is eliminated. Such a unit has been successfully operated at the D.A. Shale site using process water as the water source.

Jacketed and insulated steam lines will transport the steam to the top of the retort. They will be installed as per the ASME Piping Code and all materials will be to A.S.T.M. standards. During retorting of the 4 retort cluster, up to 129,000 lbs/hr of steam will be required for the 150' x 405' retorts and 85,000 lbs/hr for the 200' x 200' retorts.

All welds will be inspected and all pipe will be hydrotested to a minimum of 1-1/2 times working pressure. Steam traps will be installed to avoid build up of condensate and bypasses will be provided at the steam traps to drain condensate at start up and avoid "water hammer". Pressure relief valves will be installed to avoid overpressure at any point in the system. A generous corrosion allowance will be used when selecting pipe wall thickness and a corrosion inhibitor will be added to the boiler feed water. Ultrasonic inspections to check the pipewall thickness will be carried out. Crack detection by ultrasonics will also be carried out. Allowances for thermal expansion will be taken into account in piping design as per the relevant National Piping Codes.

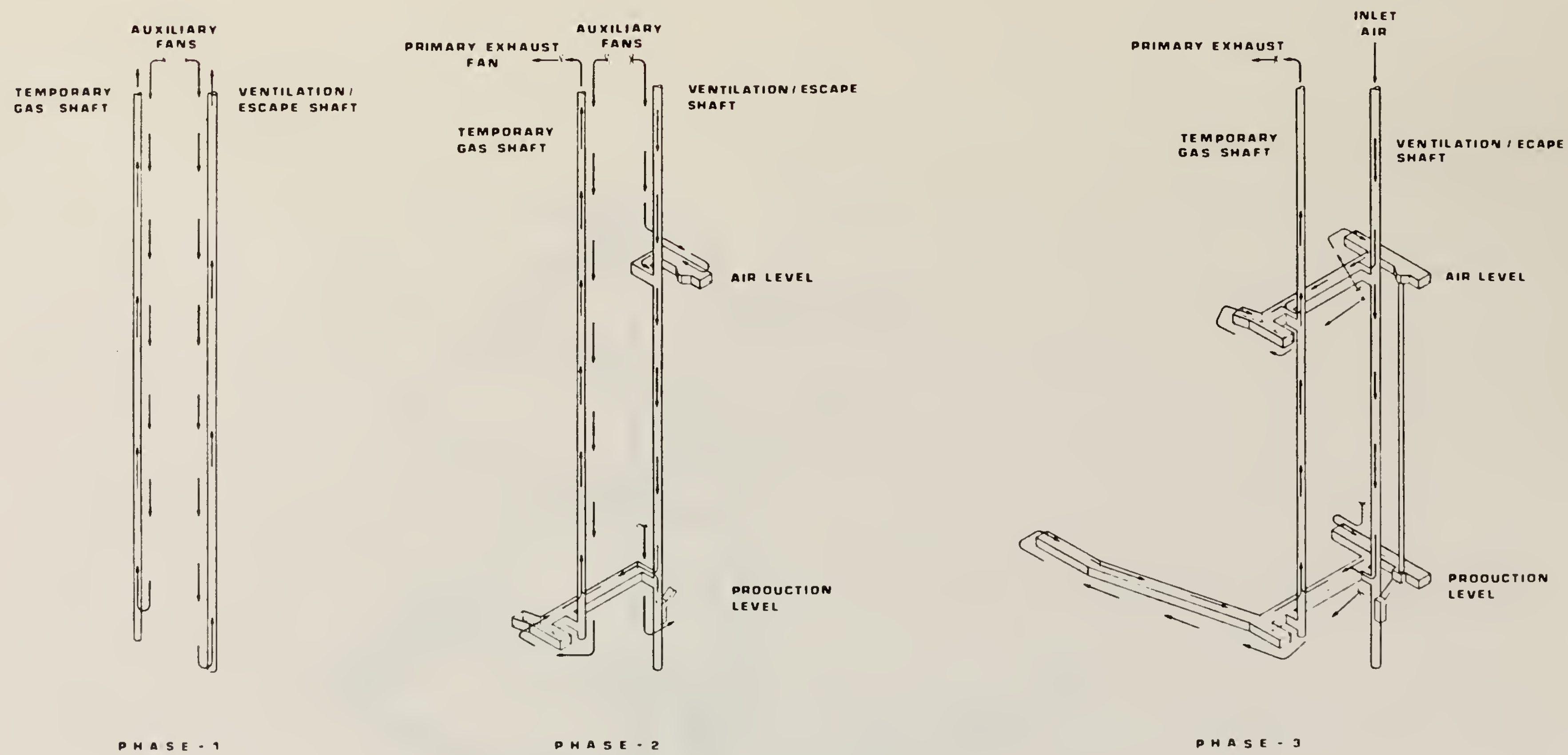
RETORT LIQUID PRODUCT HANDLING SYSTEM

Oil and process water produced in the retort will be collected in a sump behind the bulkhead or a tank outside the bulkhead. Due to the physical layout of the product drifts behind the bulkhead, several days production could be stored in the event of an exit line blockage or pump failure. Initial separation of the oil and water will take place in the collection sump and they will be pumped separately to the surface. The pumps will be contained by a concrete berm or will be installed in a concreted depressed area to restrict leakage from pump seals, etc. Pressure relief valves relieving back to the collection sumps will be installed. All lines will be designed, installed and tested as per National Piping Codes with generous corrosion allowances taken into account in the design. Pipe wall thickness will be monitored and corrosion coupons will be installed. All materials will be specified to A.S.T.M. standards.

The pumping station will be well ventilated and all electric motors in the contained pumping areas will be according to National Electric Code specifications.

STEAM LINE AND PRODUCT PIPEWAYS

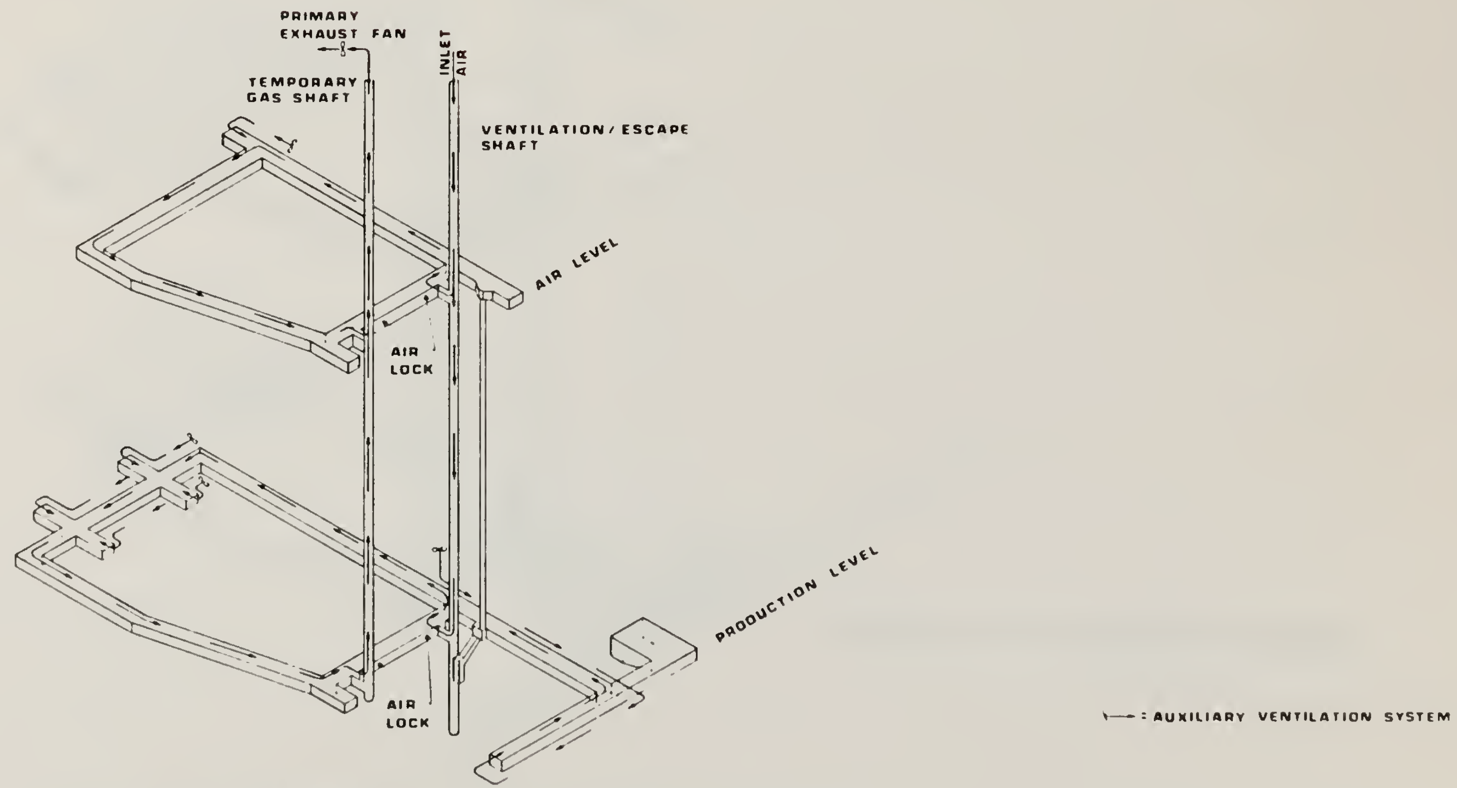
All horizontal lines will be run on substantial hangers or pipe supports so located to protect them from damage by mobile equipment. All hot lines will be insulated and jacketed to provide both personnel protection and reduce heat loss. Lines running between the surface and the mine levels will be supported by brackets in the 15 feet shaft. They will be so located to provide for easy inspection and shielded to provide for personnel protection in the case of a leakage.



VENTILATION CIRCUITS DURING DEVELOPMENT

—— : AUXILIARY VENTILATION SYSTEM

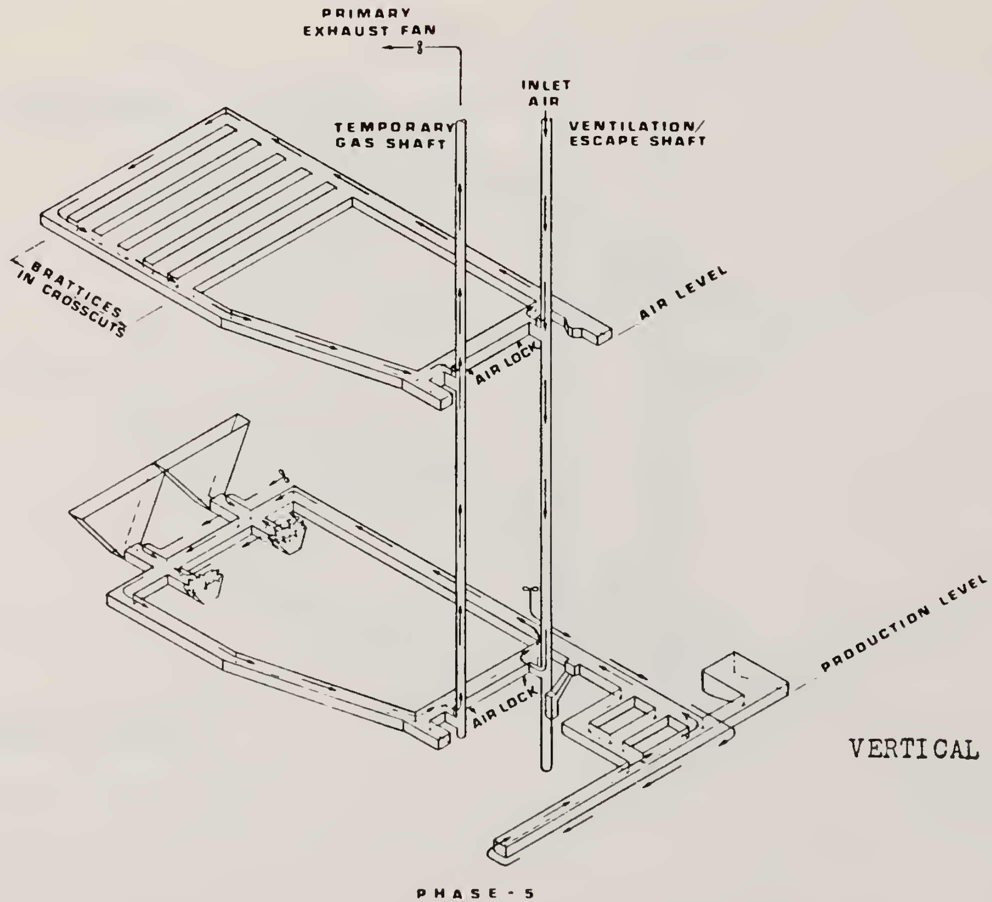
C b SHALE OIL VENTURE



PHASE - 4

VENTILATION CIRCUITS DURING DEVELOPMENT

C b SHALE OIL VENTURE

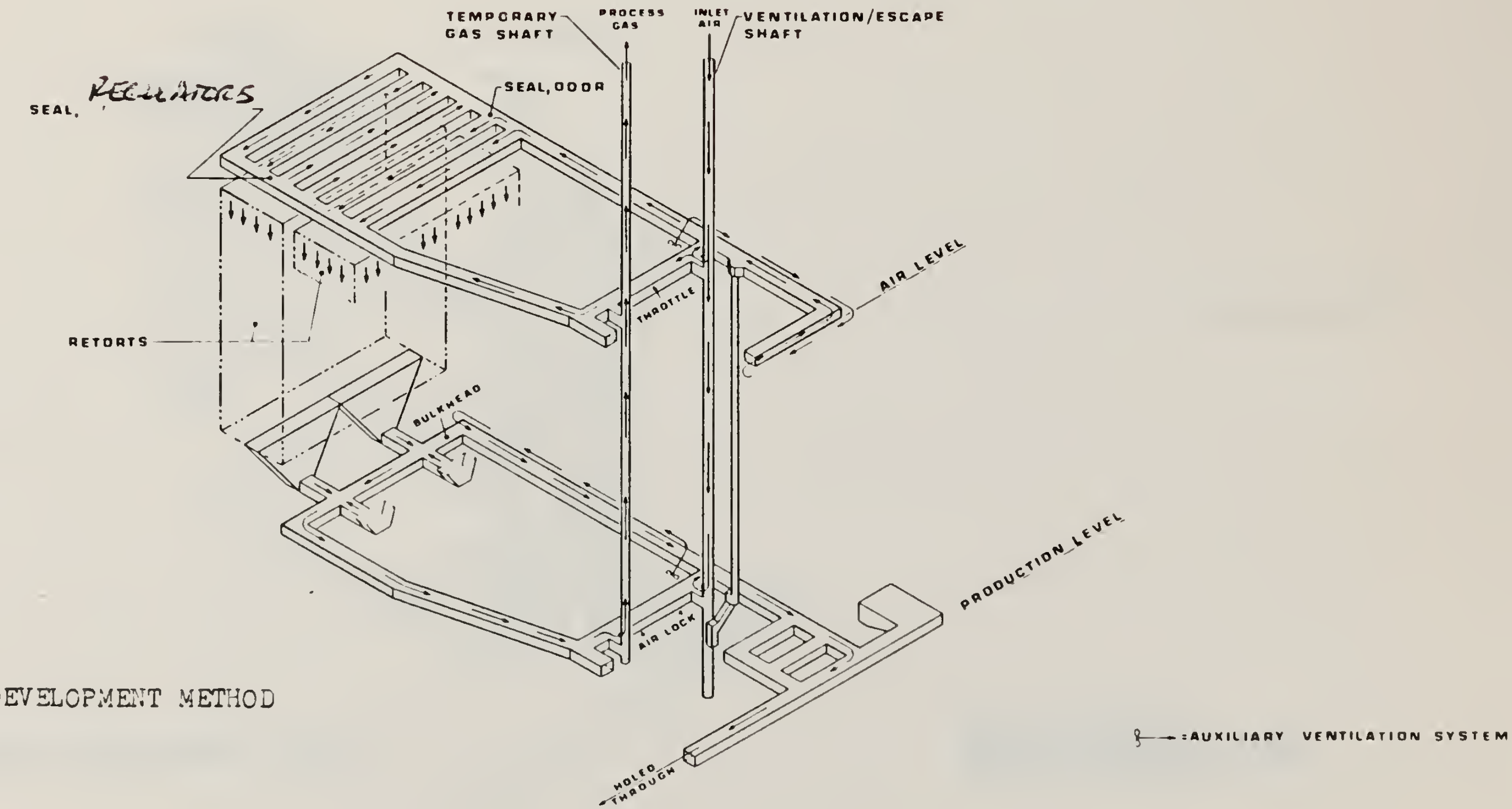


VERTICAL SLOT DEVELOPMENT METHOD

ɣ — - AUXILIARY VENTILATION SYSTEM

VENTILATION CIRCUITS DURING DEVELOPMENT

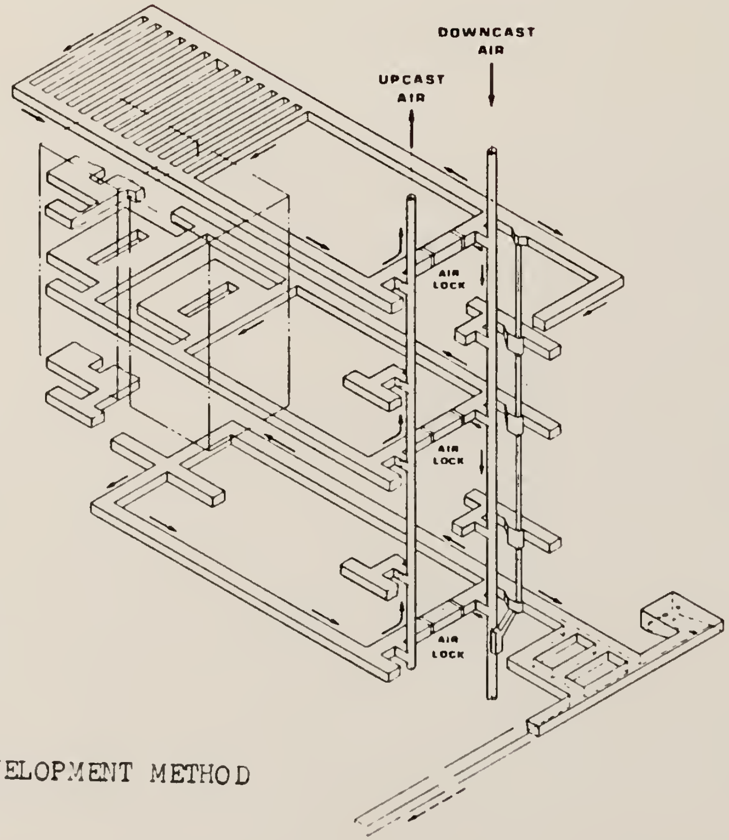
C b SHALE OIL VENTURE



VERTICAL SLOT DEVELOPMENT METHOD

VENTILATION CIRCUITS DURING RETORTING

C b SHALE OIL VENTURE



℄ BULKHEADS AS REQUIRED

MULTIPLE LEVEL DEVELOPMENT METHOD

H.F.F. RETORTS
VENTILATION AIR FLOW
(PRIOR TO RETORTING)

C b SHALE OIL VENTURE

C-b SHALE OIL VENTURE

ROCK MECHANICS PROGRAMS

FOR

STABILITY OF MINE OPENINGS

SUBSIDENCE

BOUNDARY PILLAR DESIGN

JUNE, 1977

IRVING G. STUDEBAKER, P.E.

ROCK MECHANICS PROGRAMS FOR STABILITY OF MINE OPENINGS, SUBSIDENCE PREDICTION AND EVALUATION, AND BOUNDARY PILLAR DESIGN

A three-phase program provides a responsive effort for the C-b mine design and a comprehensive monitoring program to evaluate predictive efforts for rock responses on both the surface and in underground working. The first part of the program is provided in detail, while later program phases incorporate the experience gained.

STABILITY OF MINE OPENINGS

A two-phase program of shaft pillar design, followed by the design of underground mine openings will provide a responsive tool for the mine design effort. The mine design effort starts in September, 1977, and mining of openings underground will start when the ancillary phase shafts are completed in mid or late 1979. The shaft pillar design study will be completed in September, 1977. These design criteria and evaluation techniques will be incorporated in the mine design which starts at that time. The significant details of the shaft pillar design study are shown in Appendix 1, and key points of the schedule are shown in Figure I.

SUBSIDENCE

The subsidence effects from mining at the C-b site are long range, thus the selection of monitoring systems and techniques are scheduled to start after the mine opening studies are well advanced. The information data and criteria developed by the earlier studies will be incorporated into the subsidence determination and evaluation plans. No significant data from subsidence monitoring will be developed until large scale mining operations are underway. The subsidence data input will be delayed for a length of time after the scheduled completion of the production and service shafts in mid 1980, and the subsequent development of several mining panels. The ancillary retort development in late 1979 and early 1980 will not provide sufficient open ground for early subsidence evaluation. However, an ancillary phase monitoring system will be installed to verify these assumptions (Figure I). The proposed study and design monitoring schedule check points are shown in Figure I. Key monitoring and design points are the start of the ancillary mining phase (September, 1979) and main mining phase (July, 1980).

BOUNDARY PILLAR DESIGN

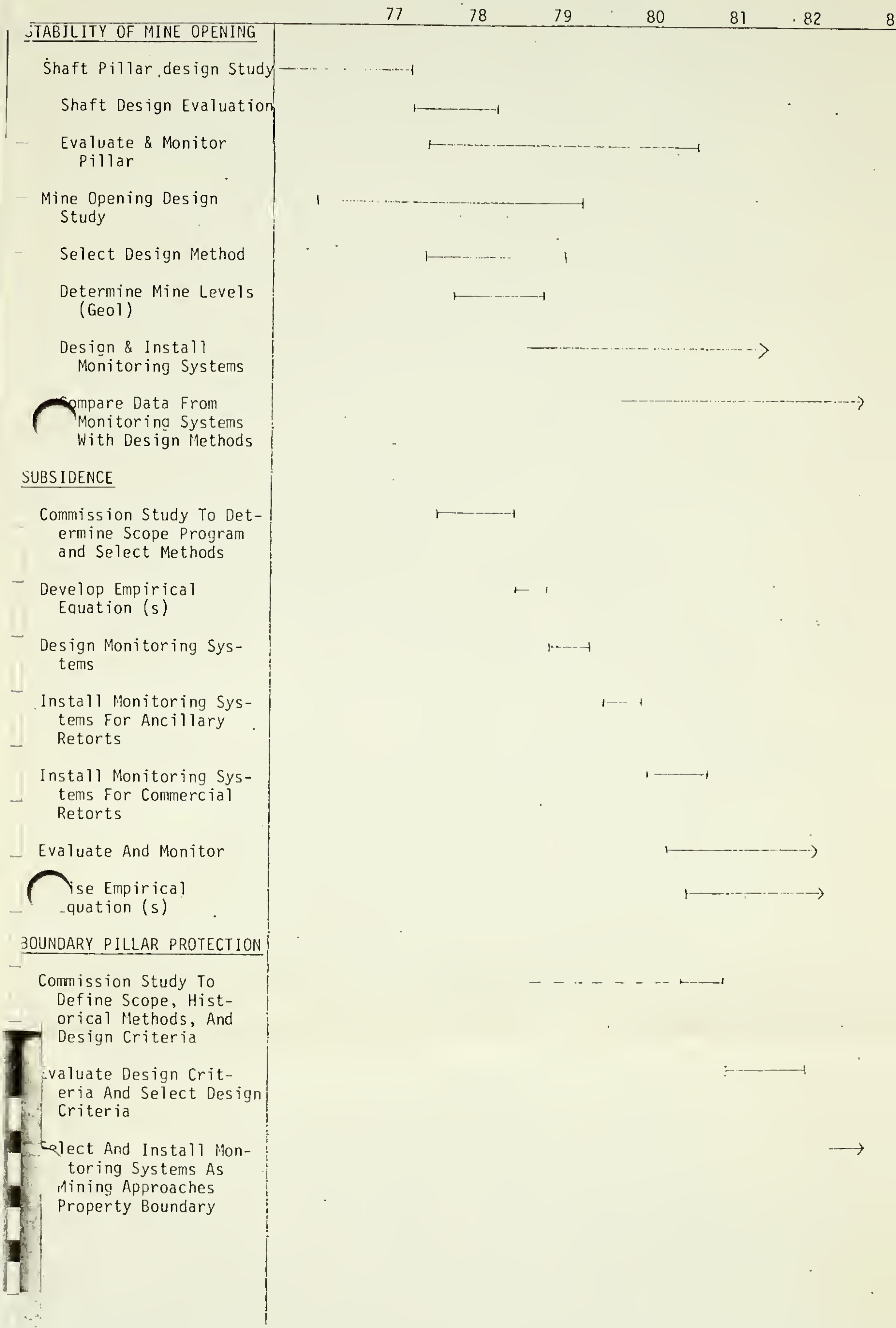
The boundary pillar design is a long-range feature, needed at the time the underground mining operation approaches the tract boundary. This design effort will incorporate the design and evaluation of the two previous phases of the above Rock Mechanics Program. Key check points in this program as indicated in Figure I, are as follows: Origination of the background study and completion by the end of 1981; evaluation of design criteria and selection of design methods in 1981; selection and installation of monitoring systems before the mining operation approaches the tract boundary.

FIGURE I.

SCHEDULE FOR ROCK MECHANICS INVESTIGATION

FOR STABILITY MINE OPENINGS

SUBSIDENCE AND BOUNDARY PILLAR DESIGN



APPENDIX I. OUTLINE

1 - Shaft Pillar Design for Oil Shale

I INTRODUCTION

II FUNCTIONS OF SHAFT PILLARS

A. Production

1. Access

2. Development

3. Ventilation

B. Subsidence protection

1. Shaft

2. Surface plant

C. Load carrying

III HISTORICAL DESIGN METHODS

A. Rules of thumb (Empirical)

B. Measurement based

1. Redmayne

2. South African (Salamon)

3. National Coal Board

4. Other

C. Examples

1. Variation in results

2. Failures

IV PILLAR LOADS AND STRENGTH

A. Tributary-area-loads (TAL)

1. Adjacent pillars

2. Arch distance effects

3. Geometry

4. Faulting

B. Strength estimation

1. Specimen method (Obert, et. al.)

    a. Size effects

    b. Shape effects

2. Probabilistic (Skinner)

3. Limiting strength (Bieniawski)

4. Empirical (Salamon & Munro)

5. Confined core (Wilson)

6. Fill confinement

V SUBSIDENCE LIMITATIONS

A. Surface manifestations

1. Vertical

2. Horizontal strain

3. Tilt

4. Angle of draw

B. Prediction

1. NCB

2. American experience

3. "Detailed Development Plan"
USBM Contract SO 241074

C. Damage reduction

1. Plant design

2. Pillar dimensions

3. Backfill

4. Allowable

5. Faulting

VI SHAFT PILLAR DESIGN EXAMPLE (Oil Shale)

A. Input conditions

1. Geometric

2. Geologic

3. Physical properties

4. Subsidence limits

   a. Horizontal strain

   b. Tilt

B. Loading

   1. Depth

   2. Density

   3. Retort effects

C. Strength

   1. Pillar

   2. Fill confinement (Blasting induced swell)

   3. Thermal effects

      a. Retorting volume change

      b. Weakening upon heating

D. Subsidence damage potential

   1. Cumulative effects

   2. Balancing effects

VII CONCLUSIONS

VIII BIBLIOGRAPHY

RETORT LEACHING/WATER MANAGEMENT

A. OBJECTIVE

(1) DETERMINE EFFECT OF SPENT SHALE CONTACT ON WATER QUALITY

(2) PREDICT QUALITY OF RESULTING GROUNDWATER

B. METHOD

(1) ESTABLISH BACKGROUND DATA ON SPENT RETORT

(2) INTRODUCE WATER OF KNOWN QUALITY INTO SPENT RETORT AT A KNOWN RATE

(3) MONITOR EFFLUENT QUANTITY AND QUALITY

(4) EXTEND TEST FOR SUFFICIENT TIME

C. RESULTS

- SHOW WHICH CONSTITUENTS ARE LEACHED AND HOW FAST

C·b Shale Oil Venture

2372 G Road — P.O. Box 2687
and Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

July 1, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
U.S.G.S. Conservation Divison
Mesa Federal Savings & Loan
131 N. 6th, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

I am sending you additional information to Section III-E-11 and V-B of the DDP Modification as requested by you describing the supporting laboratory program plan for the shale leaching investigation.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason
Manager, Leasehold Development

RET:pmr

Encl.

cc: J. J. Hill
R. A. Loucks
R. J. Fernandes

29 June 1977

Occidental Oil Shale, Inc.
Oil Shale Laboratory Leaching Program

1. Purpose

On behalf of Occidental Oil Shale, Inc., and as part of its research program to support oil shale activities, Occidental Research Corporation has planned and initiated a comprehensive laboratory program to study the water leaching of oil shale. The study has two general objectives: (1) to define the problem, i.e. to determine what constituents are leached, under what conditions, and how fast; (2) to determine what steps may be required to obviate any potential water quality problems due to water which has come in contact with oil shale. The program described below addresses itself to the first objective.

2. Discussion

The ORC oil shale leaching program has two major and related elements: the execution of an extensive series of laboratory leaching experiments and the development of a mathematical model which represents and correlates the experimental results. The ultimate use of this work will be to accurately predict leaching behavior under field conditions.

Because the program is in its early stages, it must now be considered flexible because much of what will be done in the future depends on what is learned initially. The basic objectives will, however, remain unchanged. The current level of effort for the study consists of a minimum of one full time research engineer as well as associated technician, administrative computer, and analytical laboratory support.

Features to be studied in the experimental program will include the following:

(1) The effect of water leaching of raw shale and of spent shale,

(2) Experiments designed to determine leaching effects under conditions of water trickling through the shale bed or the bed being flooded with water.

(3) The effect of leaching (water) rate.

(4) The effect of shale particle size.

(5) The effect of shale history. This is important for spent shale and will include the retorting conditions the shale has seen, e.g. temperature.

This work is part of a larger program Occidental is undertaking to determine the effect of water contacting oil shale. The other two parts are mentioned below.

(1) A field test in Retort 3E, D. A. Shale in which water of essentially groundwater quality, will be injected into the retort under controlled conditions and the results carefully monitored.

(2) A continuing program in which water quality in the D. A. Shale project area is constantly and carefully monitored. Special attention is paid to water which has come in contact with spent retorts.

Proposed Field Study of Spent Shale Leaching

Retort 3E, D. A. Shale

1. Objective

Environmental advantages have been demonstrated for in-situ processing of oil shale compared to surface processing in all facets for which a comparison can be made. From an environmental point of view, a major difference between in-situ and surface processing is that the in-situ process produces underground retorts filled with spent shale as opposed to surface dumps of spent shale. The spent shale contained in underground retorts has experienced a different history from that produced by surface processing. Therefore leaching and other water contacting tests conducted on surface retorted material are not directly applicable.

A reasonable concern has developed regarding how the quality of water, which has somehow entered a retort, will be affected by contact with the spent shale. Since water leaving a retort may finally become part of the local ground water supply, the ultimate concern is for the quality of the ground water. Water having passed through a retort can be pumped out, collected and upgraded to acceptable standards. The extent that such treatment will be required will be indicated by the program proposed.

Occidental Oil Shale, Inc. has proposed a three-pronged program to determine the effect of water contacting in-situ retorted spent shale.

(1) Field tests in which spent shale in retorts is contacted by water under controlled conditions and the results are carefully monitored.

(2) An extensive laboratory leaching program from which the results may be extended to field conditions. This work will include the development of a mathematical model to enable accurate predicting of leaching behavior to be made.

(3) A continuing water quality monitoring program which gathers extensive quality data on ground water in the project area and particularly that which has come in contact with spent shale in abandoned retorts.

The purpose of the test proposed here is to obtain data, under field conditions, which will enable predictions to be made regarding the quality of the water that comes in contact with in-situ spent shale. The predictions are intended to cover an extended period of time after retorting has been completed. This test is a significant part of Occidental's continuing demonstration of responsible concern for environmental aspects of its oil shale program.

The specific objectives of the proposed test are:

(1) To inject water of known quality and at a known rate into Retort 3E, D. A. Shale, and to monitor the quality and quantity of the effluent. We will be looking for evidence of leaching of both inorganic and organic materials. Particular attention will be paid to any evidence of polynuclear aromatic hydrocarbons in water leaving the retort. Of great importance will be the determination of the maximum concentration reached by any pollutants in the effluent water.

(2) To determine the residence time for the water injected into Retort 3E using tracer techniques.

2. Summary

Retort 3E, D. A. Shale is a promising site for the proposed test. Two major reasons are that it is relatively small and that it seems to be nearly dry. Efforts are currently being made to estimate the background flow of water in Retort 3 and the quality of any water found. Because it has been dry, no data are available on the quality of water exiting Retort 3 since May 1975 when the room was being retorted.

The proposed test is planned to run for a minimum of three months once it is under way. Water, substantially the same as local ground water and obtained from local sources, will be injected into Retort 3 at a rate of two gallons per minute. A total of 288,000 gallons of water will be required for a test of three months. It is proposed to deliver the required water to the top of Retort 3E by truck, store the water in tanks currently located there, and then deliver the water to Retort 3E through an existing distribution system. Based on the rates determined, 2880 gallons per day must be delivered to the site. For a truck of 2000 gallon capacity this will mean about one and on half trips per day. There are three 25,000 gallon and one 10,000 gallon storage tanks available at the site. For this test, one 25,000 gallon tank will be required.

It is proposed to pump out Retort 3E daily (or as required) in order to estimate the exiting flow rate and to avoid building up of any substantial amount of water in Retort 3E. This water will be disposed of by current methods for mine water or process water depending on its quality.

Since the exiting water flow rate is unknown at this point it is impossible to accurately forecast an optimum sampling frequency for water quality analysis. It is tentatively proposed to sample weekly and more frequently if required. On a bi-weekly basis, a complete water quality analysis will be made. See Appendix A for a complete list of the items currently analyzed. In addition, analysis will be made for polynuclear aromatic hydrocarbons on a bi-weekly basis. On a weekly basis, the effluent water will be analyzed for evidence of both salts and organic materials. A proposed list of the items to be included in the weekly analysis is shown in Appendix B. During residence time studies, the tracer selected must also be monitored, possibly daily.

3. Discussion

A. Basis for experimental design.

There are no generally available data on the leaching of spent shale which has been retorted in-situ. As a result, the predicted behavior of the proposed test has been based on the data obtained by John Shafer of Occidental Research in 1976.[1]

In this work Shafer studied the leaching of Na^+, K^+, and $SO_4^=$, ions as a function of time at a fixed water irrigation rate. Experiments were performed with samples of spent shale retorted under in-situ conditions at ORC's La Verne Laboratory. However, the conditions were not the same as those of Retort 3E and therefore any predictions for the behavior of the field test based on these data serve only as general guidelines.

After 150 days, it was determined that essentially all of the salts monitored had been leached from the spent shale. Ion concentrations in the effluent ranged from 170 to 1350 mg/l for Na^+; 73 to 240 mg/l for K^+, and 370 to 1220 mg/l for $SO_4^=$. For comparison, a water quality sample dated 12/21/76 taken from Retort 2E, D. A. Shale, showed 500 mg/l for Na^+; 400 mg/l for K^+, and 1040 mg/l for $SO_4^=$. Shafer also determined the holdup of water on spent shale to be about 0.41 pounds per pound of shale. This is the water remaining behind when a flooded column of spent shale is drained. Again, this figure must be considered only approximate for retort conditions, in part because of the much larger particle sizes encountered.

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[1] John Shafer, Oil Shale Leaching Report, 17 November 1976, Occidental Research Corporation

B. Predicted test results.

Shafer's data have been interpreted to mean that the amount of salt leached from the spent shale is primarily dependent on the total amount of water which has contacted the spent shale. That is, the results are not dependent on the rate of injection. Based on this, it is estimated that as much as 8% of the salts in place may be leached out during the first three months of the proposed test.

Retort 3E is essentially 1055 square feet in area by 113 feet deep. A volume of 119 thousand cubic feet. The retort has an estimated porosity of 25.9% and thus contains 88.2 thousand cubic feet of spent shale. Approximately 5600 tons of spent shale are estimated to have been retorted.

Based on the above, two cases were considered. In each case the inlet water is assumed to be supplied at a constant rate of two gallons per minute or 2.57×10^{-4} gallons of water per pound of spent shale per day.

In case 1, the spent shale was considered to be dry. It was also assumed that all the holdup water would be accumulated in the bed before any exit water would appear. If these conditions prevail, it would take 192 days (5.5×10^{5} gallons of water) before any effluent water would be seen.

For case 2, the retort was considered to be saturated with water. In this event, effluent water will appear as soon as water injection starts. The estimated test results appear below.

TABLE 1
Estimated Test Results
(Retort Initially Water Saturated)

	Total Water	% Initial Salts Removed		
Day	Gallons	Na^+	K^+	$SO_4^=$
0	0	0	0	0
30	86×10^3	3	2	3
60	172×10^3	6	4	6
90	259×10^3	8	6	8

The actual test situation should be something between the two cases considered. This is primarily due to two factors. First, the retort is probably partially wet with some local saturation. Second, while the

injected water may be fairly well distributed initially, it probably will not percolate down uniformly through the bed, but will channel. Again this leads to local saturation and an unpredictable time for effluent water to appear.

C. Tracer Studies.

Use of a tracer is recommended in order to estimate the residence time of water in the bed. Tritium, in the form of tritium oxide, is suggested as the best tracer if approval for its use is obtained in a timely way. Tritiated water should behave chemically just as pure water during the test. If approval for the use of tritium is not obtained, the use of chemical tracers is in order. Because a chemical tracer may itself be absorbed on the spent shale the simultaneous use of two tracers may be advisable in order to detect this possibility. Potential chemical tracers are flourescene dye, lithium chloride, and lanthanum injected as the chloride or nitrate. The use of lanthanum is dependent on atomic absorption analysis being available.

The purpose of the tracer studies is to estimate the time spent by the injected water in the bed. The tracer would therefore be injected as a pulse. If permission for use is obtained, it is suggested that tritium in the form of tritium oxide be mixed with water at a concentration below the minimum permissible content established by Government regulation, and then be injected into the retort over as short a period as would be consistent with good test results. A similar procedure would be followed for use of chemical tracers.

The tracer study may be started any time after a steady effluent flow has been established. If no entering ground water is assumed for Retort 3E, then the steady effluent flow must be equal to the steady water injection rate.

The background water flow in Retort 3 is very low. It has therefore been assumed that water holdup in the retort can be calculated satisfactorily from a balance on the injected and effluent water.

D. Test Procedure.

It is proposed to inject water of essentially ground water quality continuously into Retort 3E at the rate of two gallons per minute. Over a three month projected life of the test this amounts to 288,000 gallons of water total. The source of water to be obtained has not been established. If water for the test is readily available it may prove advantageous to increase the proposed water injection rate in order to accelerate the test. On the other hand, if water for the test is limited, then it may be necessary to reduce the proposed injection rate.

Prior to injection, the water will be held in storage tanks available above Retort 3E. The proposed rate of water injection requires on the average 2880 gallons of water per day be delivered to the site. It is expected that delivery will be made by 2000 gallon capacity trucks making one to two trips per day. To provide stored water for five to ten days operation, about 20,000 gallons should be stored at any one time. This will require the use of one of the 25,000 gallon tanks available. It is proposed to use the existing pumping and distribution system for injecting the test water into Retort 3E.

Effluent water will be removed from Retort 3E with an existing pump and existing piping. At this point, it is proposed to dispose of the effluent water in one of a variety of ways depending on its quality. If the quality is good, it can be used as mine water is now used, e.g. for drilling equipment or boiler feed water. If the effluent water quality is not sufficiently high for those purposes it can possibly be sprayed on roads or dumps.

It is proposed to sample both injected and effluent water for water quality analysis on a weekly basis. A complete water quality analysis (an already established test, see Appendix A) should be done on a bi-weekly basis. Also on a bi-weekly basis, analysis will be made for polynuclear aromatic hydrocarbons. On a weekly basis, analysis will be made for indicators of the leaching of both salts and organic materials. Appendix B contains a suggested list of items to be checked. During the period covered by the tracer studies, analysis must also be made for the tracers. The frequency of sampling during tracer studies may have to be greater than once a week.

E. Analytical Procedures and Methods.

At present, water quality sample analysis for D. A. Shale is being performed by Coors Spectro-Chemical Laboratory of Golden, Colorado. Two analysis are currently being made at the discretion of OOSI and depending on the situation. The complete analysis consists of some 68 items. A less complete and less expensive anlaysis consists of 31 items. The Coors analytical work has proved very satisfactory, it somewhat costly. The tests currently cost $527.00 for the complete analysis, and $213.50 for the less complete analysis. A major advantage of the Coors service is that prepared sample containers are provided, which makes sampling in the field relatively easy and straight forward.

For the proposed leaching test it is planned for the OOSI laboratory in Grand Junction, the Occidental Research Laboratory in La Verne, and Coors Spectro-Chemical Laboratory to all participate in the water quality analysis.

The specific tests that each laboratory will perform have yet to be worked out, but will be decided on the basis of cost and capability. It is planned for the OOSI laboratory in Grand Junction to monitor the tracer studies. Analysis for polyaromatic nuclear hydrocarbons will be performed by the Parma Technical Center of Union Carbide Corporation.

There is a considerable advantage to having a full water quality analysis capability within Occidental. Substantial savings should result over the long run. At this point, the details of ORC's water quality analysis capabilities and procedures have not been fully established. In addition, procedures for sample container preparation and delivery to the project site, and sample return to La Verne have yet to be worked out.

F. Field Equipment.

It is planned to use exisitng storage tanks and an existing pumping and piping system to inject the test water into Retort 3E. Above Retort 3E there currently exist three 25,000 gallon and one 10,000 gallon storage tanks. During the test it is projected that one 25,000 tank will be used. It is presently believed that the existing system will prove adequate for pumping, metering, and delivering the test water to Retort 3E.

It is also proposed to use existing equipment to pump out and sample Retort 3E. (Additional equipment in the form of water trucks may be needed to dispose of the effluent water.)

Water for the proposed test will be obtained from off site sources. The rate of water injection will require, on the average, 2880 gallons per day of water delivered to the top of Retort 3E. If trucks of 2000 gallon capacity are used, one and one half trips per day will be required.

Any additional equipment or apparatus required for the proposed test should be both minor and available.

4. Cost

The cost of the proposed test is currently being estimated. External to OOSI, the additional costs will be those of obtaining, delivering, and disposing of the test water and the costs of water quality sample analysis. Direct manpower requirements for OOSI are estimated to be about two man days per week to generally perform the test, and to take samples for analysis, and to perform some water quality analysis. Analytical support from ORC is currently budgeted as are Claremont Engineering charges.

Over a three month projected lifetime of the test, 288,000 gallons of water will be required. The cost of this water, essentially the cost of delivery, is now being estimated. The cost of disposing of the test water should be small, but is also being estimated.

Costs for water quality analysis are based on weekly "short" and bi-weekly complete water quality analysis for both the injected water and the effluent water. Occidental Research is now estimating the cost for its analysis. Shortly it should be possible to make a reasonable estimate of both the analytical costs required for the proposed test and of the total extra costs for the test.

APPENDIX A

Water Quality Analysis

Complete List of Items Currently Analyzed*

Pesticides (Chlorinated), μg/l

Color, Platinum Cobalt Scale*

Specific Conductance, μmhos*

Turbidity, FTU*

pH*

Total Alkalinity, mg/l$CaCO_3$*

Bicarbonate, mg/l $CaCO_3$*

Total Organic Carbon, mg/l*

Suspended Solids, mg/l*

Soluble Solids, mg/l*

Volatile Solids, mg/l*

Sulfate (SO_4), mg/l*

Hardness, mg/l $CaCO_3$

Chloride, mg/l

Fluoride, mg/l*

Chemical Oxygen Demand, mg/l*

Odor, ASTM OII*

Fecal Coliform Bacteria Colonies/100 ml

Phenol, mg/l*

Phosphorus, mg/l

Sulfite (SO_3), mg/l*

Bromide, mg/l*

Nitrogen-Kjeldahl, mg/l*

Nitrogen-Ammonium, mg/l*

Nitrate, mg/l*

BOD_5, mg/l*

Oil and Grease, mg/l*

Sulfide, mg/l

Nitrite, mg/l

Cyanide, mg/l

Surfactants, mg/l

Silicon, mg/l

Lithium, mg/l*

Sodium, mg/l*

Potassium, mg/l*

Arsenic, mg/l*

Selenium, mg/l

Mercury, mg/l

Cadmium, mg/l

Zinc, mg/l*

Iron, mg/l*

Magnesium, mg/l

Calcium, mg/l

Boron, mg/l*

Thallium, mg/l

Chromium, mg/l*

Vanadium, mg/l*

Cobalt, mg/l

Nickel, mg/l*

Strontium, mg/l

Copper, mg/l*

Barium, mg/l

Manganese, mg/l

Silver, mg/l*

Zirconium, mg/l*

Titanium, mg/l

Molybdenum, mg/l

Antimony, mg/l*

Tin, mg/l

Gallium, mg/l

Lead, mg/l

Aluminum, mg/l

Beryllium, mg/l

Yttrium, mg/l

Scandium, mg/l

α, pCurie/l*

β, pCurie/l*

Radium 226*

---

* Items so marked are included on the "short analysis".

APPENDIX B

Water Quality Tests

(Weekly or Greater Frequency)

Specific Conductance, μmhos

pH

Total Alkalinity, μg/l $CaCO_3$

Total Organic Carbon, μg/l

Sulfate (SO_4), μg/l

Fluoride, μg/l

Chemical Oxygen Demand, μg/l

Phenol, μg/l

Nitrate, μg/l

BOD_5, μg/l

Sodium, μg/l

Potassium, μg/l

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
P.O. BOX 3395, UNIVERSITY STATION
LARAMIE, WYOMING 82071

LARAMIE ENERGY
RESEARCH CENTER

May 26, 1977

RECEIVED
MAY 31 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

Peter A. Rutledge
Area Oil Shale Supervisor
USDI - Geological Survey
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501

Dear Pete:

As you requested, I'm outlining the stories I told about thermal reactions of oil-shale minerals to the advisory group you assembled May 16 in Grand Junction. Because oil-shale is a bit variable, I can't cover all angles in a letter. So I'll present a general picture and encourage questions.

The temperatures reached by rocks in a modified vertical in-situ retort are relatively high - perhaps 2200°F. This contrasts sharply with the 1300°F temperatures found in LERC's 150-ton retort. Although gas-flow rates helped generate this difference, a primary factor producing the higher temperatures in the underground retort is that it loses no heat from its edges.

The higher temperatures attained in the subsurface retort create marked changes in the minerals. In the 150-ton retort, reaching 1300°F, dolomite is broken down to calcite and to magnesium and iron oxides:

$$(Mg,Fe)Ca(CO_3) \longrightarrow (Mg,Fe)O + CaCO_3 + CO_2$$

At this temperature calcite begins to undergo decomposition:

$$CaCO_3 \rightarrow CaO + CO_2$$

At the higher temperatures reached in the in-situ retort these carbonate decomposition reactions go to completion and a new reaction series is initiated. The CaO is an extremely active material at the temperatures where it is produced. It reaches out, grabs the surrounding minerals and forms new compounds by what are called solid-state reactions.

I'm enclosing a copy of a thermal analysis review which describes solid state reactions on pg 621-622 and even indicates how active CaO is. The minerals available for CaO to react with include quartz, soda feldspar, and potash feldspar plus the iron and magnesium oxides from carbonate

7700743

decomposition. An article describing this attack is cited in the middle of page 622. The formation of diopside from oil shale minerals is mentioned on page 607. Time substitutes somewhat for temperature so the 1100°C (~ 2000°F) is higher than when diopside and its relatives actually appear.

The solid state reaction of CaO with the silicates is exothermic - that is it generates heat. This helps the reaction to continue. In oil shale the mineral particles are all very small and are intimately mixed. This also helps the reaction go to completion.

Diopside is not the only mineral that may form. Others include augite and mellilite as representatives of rather large mineral families. These merely represent the adjustments made in the crystals to accommodate whatever materials are handy. All of these minerals formed share one characteristic important to oil shale development - they are insoluble in water.

Two things you should also know about include the fact that I picked up a block of shale from the wall in Oxy's Chamber. It's the one that I had on the table. It is extremely porous and full of water. That's why I had it in a plastic bag. The water had been there since the rock cooled enough to let it in and had not circulated thru. This water was almost neutral - pH 6.5 to 7. The burn edges showed calcium carbonate precipitates. Apparently there is enough carbonate available to kill the free lime. In addition, the mineral thenardite showed up right along the edge of the burn. This is a neutral salt (pH = 7). No strong base development as Glenn predicted!

At LERC we have a program going to define these high temperature mineral changes. They don't work in powdered oil shale quite as well as they do in the rock because the mineral particles are farther apart in the powder. But they still go! We expect publication within 4 months and will put you first on the list to receive a copy.

We hope this helps.

Sincerely yours,

Ward

John Ward Smith
Division Manager

Enclosure:
As stated

WATER MANAGEMENT

Aquifer characteristics of primary importance are summarized in memo reports dated 5/19/77 and 6/9/77 submitted here as supporting information from Energy Consulting Associates.

Estimated dewatering rates have been made by Tipton & Kalmbach dated 5/17/77, and are submitted here as supporting information. These estimates consider the mine as a two-aquifer system. The top of the Mahogany zone serves as the base elevation for the purpose of this definition. The upper dewatering zone is located approximately 40 feet above the top of the Mahogany zone and will handle all the water which drains into the mine from that point.

The lower zone is located at approximately the base of the L-5 and will handle all the water which drains into that level comprising the zone from the top of the Mahogany to the base of the L-5. There may also be some up-flow from below the L-5.

For the purpose of water quality control, water from these two levels may be handled separately as it suits the ultimate discharge/use point and to minimize treatment costs.

These data provide the basis for engineering design of water systems.

It is assumed the continual removal of water in the quantities estimated as being required may result in the eventual reduction of stream and spring flow which would, in turn, adversely affect the holders of senior water rights.

Work has been underway for some time to secure adequate long-term water rights. These water rights serve as a basis for a water augmentation plan currently being prepared by Tipton & Kalmbach, Consulting Engineers, to submit to the water court. Details of this water augmentation plan will be made available just as soon as the preliminary options are finalized. It is expected that primary augmentation water will be available from the White River under these rights.

The management of on-tract water resources covers a broad spectrum of options. They include:

> Recirculation within the production system of mine water, process water, well water; and subsequent use for mining, processing, revegetation, dust control, domestic and sanitary needs. Treatment, reinjection and storage may be utilized.

A range of water quality is evident from the existing test data so that separation as to source and use is available and may be required.

Early on in the project development there will be more water produced than can be consumed. This surplus water may be handled in some of the following ways:

- discharge into the Piceance Creek
- discharge into the White River
- subsurface reinjection
- holding in suitable lined ponds/reservoirs, evaporation ponds
- irrigation of range land or revegetated areas on tract.

Dewatering during sinking and drilling of shafts will be at a controlled minimum. Water inflow will be controlled by grouting on the larger shafts and mud drilling on the small shafts.

Where discharge of water into the stream system occurs, the quality and quantity of the discharge water will be regulated according to permissible levels, by treatment, if necessary. Discharge water quality will be within the existing regulations. The application for permits necessary to discharge and/or reinject are being prepared and discussions are under way with the Colorado State Water Quality Control Division.

2 WQ-5

TIPTON AND KALMBACH, INC.
ONE PARK CENTRAL, SUITE 1401
1515 ARAPAHOE STREET
DENVER, COLORADO 80202
PHONE (303) 572-8081

OLIN KALMBACH, PRESIDENT
C. W. MEHRING, EXEC. VICE PRES.
D. W. GREENMAN, VICE PRES.
R. C. BOLGER, VICE PRES.
A. J. DEUTSCH, TREASURER
F. L. KIRGIS, SECRETARY

May 17, 1977

Mr. Robert E. Thomason
Occidental Oil Shale, Inc.
2372 G Road
Post Office Box 2687
Grand Junction, Colorado 81501

MAY 18 Rec'd

Subject: Estimated Pumpage from Cb Mine

Dear Mr. Thomason:

Attached is a table showing the range of pumpage to be expected in dewatering the mine area at Cb. As discussed, the effective storativity of the aquifers is still unknown and will remain so until operations are well under way.

Predicting quality of discharge is also a matter of judgement owing to the range in quality of groundwater on and near the tract, mixing of waters from above and below the "A" groove through exploration wells, apparent errors or inconsistencies in analyses, and the unpredictable effect of vertical leakage. In our estimates of the impact of mine drainage water on the quality of surface streams (which is schematically portrayed on the several small maps we gave you) we used values of dissolved solids and fluoride as follows:

	TDS-ppm	F-ppm
Upper aquifer	970	3
Lower aquifer	1200	15
Average pumpage	1040	7

There is some evidence to indicate that the fluoride content of the upper aquifer may be significantly higher than the above value, and vertical leakage, particularly upward leakage, could affect the quality of the water pumped from the mine.

Sincerely,

Olin Kalmbach

OK:rs
Attachment
cc: Ashland - Mr. Hill (w/encl.)
ECA - Mr. Chestnut (w/encl.)
Claremont - Mr. Ruskin (w/encl.)
Parsons - Mr. Shaw (w/encl.)

P.S. The map showing the case of "Treated Mine Discharge" we gave you was blurred and 10 copies of a new print are enclosed.

Development Period

Project Year (1)	Area Developed (acres) (2)	Estimated Mine Inflow - gpm: From Upper Aquifer (3)	From Lower Aquifer (4)	Total Upper and Lower (5)
1 (1977)	0	0	0	0
2 (1978)	1 Drilled Shaft	300 - 300	200 - 200	500 - 500
3	4 Shafts	1300 - 3200	500 - 1450	1800 - 4650
4	100	2300 - 5800	1100 - 3000	3400 - 8800
5	200	2600 - 5800	1150 - 3200	3750 - 9000

Estimated Inflow to Mine

Project Year	Area Developed (acres)	Estimated Inflow to Mine - gpm: From Upper Aquifer	From Lower Aquifer	Total Upper and Lower
(1)	(2)	(3)	(4)	(5)
0-5 (Development period - see estimates on Sheet 1)				
6	300	2600 - 6100	1200 - 3450	3800 - 9,550
11	700	2650 - 6250	1300 - 3600	3950 - 9,850
16	1100	2650 - 6500	1250 - 3700	3900 - 10,200
21	1500	2650 - 6500	1250 - 3700	3900 - 10,200
31	2300	2700 - 6500	1300 - 3800	4000 - 10,300
41	3100	2700 - 6500	1300 - 3800	4000 - 10,300
51	3900	2650 - 6600	1300 - 3800	3950 - 10,400
60	4620	2600 - 6600	1300 - 3750	3900 - 10,350

Values in Column (2) are based on a production rate of 57,000 bbl/day and an average increase in the mine area dewatered of 80 acres per year.

"Boundary" between upper and lower aquifers is assumed to be at the tap of the Mahogany Zone.

Upper aquifer is assumed to extend down to air level or 1,100 feet belaw original water level.
Lower aquifer is assumed ta extend from air level down ta gas level, 1550 feet below ariginal water level.
Ranges in values shown in Cals. (3) thraugh (5) are based on an assumed range in storativity of 0.001 and 0.05 respectively.

2.1.1

ENERGY
CONSULTING ASSOCIATES

MAY 26 RECD

May 19, 1977

RECEIVED

JUN 28 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

Mr. Robert E. Thomason
Leasehold Manager
Occidental Oil Shale, Inc.-OXY
P.O. Box 2687
Grand Junction, Co. 81501

Dear Mr. Thomason:

As per your assignments during the meeting in Tipton and Kalmbach's offices on May 13, 1977, we have prepared the following materials and are hereby transmitting them to you:

1) A tabulation of the aquifers deduced from the pump/spinner tests in wells 32X-12 and 33X-1; these tables contain estimations of the requested aquifer properties.

2) A graphical display of predicted discharge from each aquifer unit during sinking of shafts in the vicinity of 32X-12. These curves are for either shaft, with the interference effects of the other shaft taken into account; for non-simultaneous sinking of the shafts, these values for discharge should be multiplied by a factor of 1.4.

3) Water quality data from the drill-stem tests in SG-17, the main aquifer pump tests, the mini-pump tests, and samples recovered while drilling 33X-1.

We believe this information will fulfill the immediate requirements of the various individuals involved in the project planning at this time, as expressed in the meeting of May 13. If there are any questions about the information presented, please contact us.

Sincerely,

Dwayne A. Chesnut

Dwayne A. Chesnut

DAC/vpm
cc: 3 to W.R. Shaw
1 to G.T. Kimbrough
1 to J.J. Hill
1 to O. Kalmbach
1 to A.M. Ruskin
1 to T.N. Beard
1 to D.C. Conner

817 SEVENTEENTH STREET SUITE 610 DENVER, COLORADO 80202 (303)623-8706

7700915

C-b Tract Well 33X-1
Aquifer Definition

Aquifer No.	Horiz Perm (Kmd)	Top of Aquifer[1] (ft)	Thickness[1] (ft)	Est. Transmissivity[1] (GPD/ft)	Equilibrium Pressure[2] (psi)	TDS[3] (mg/l)	Fluoride[3] (mg/l)	Boron[3] (mg/l)
1	?	350	50	?	22	1050[4]	0.1[4]	0.08[4]
2	?	650	65	?	144	1050[4]	0.1[4]	0.08[4]
3	?	750	60	?	186	1050[4]	0.1[4]	0.08[4]
4	90	900	25	40	244	1050[4]	0.1[4]	0.08[4]
5	130	943	47	113	267	1050[4]	0.1[4]	0.08[4]
6	260	1080	20	93	320	540	12	1.2
7	80	1130	45	67	347	750	16	1.4
8	550	1210	34	340	380	995	10	0.3
9	190	1315	25	87	423	680	18	1.8
10	140	1385	80	200	465	735	10	0.1
11	260	1504	21	100	504	581	17	0.5
12	75	1620	55	73	562	800	20	0.5
13	75	1680	30	40	582	1150	25	1.4
14	100	1815	35	67	642	2175	25	1.1
15	100	1850	55	100	661	595	8.9	0.9
16	710	1905	14	180	676	1480	20	1.8
17	250	1950	90	400	712	2500	45	0.9

1) As shown by the Pump/Spinner test of 5-7-77; all depths are measured from the kelly bushing

2) Computed from hydrostatic gradient to the midpoint of the aquifer from a static water level at 350 ft.

3) Based on stratigraphic correlation to water samples taken during the drill-stem tests on SG-17

4) Based on the Uinta water sample from 33X-1

C-b Tract Well 32X-12
Aquifer Definition

Aquifer No.	Top of Aquifer[1] (ft)	Thickness[1] (ft)	Est. Transmissivity[1] (GPD/ft)	Equilibrium Pressure[2] (psi)	TDS[3] (mg/l)	Fluoride[3] (mg/l)	Boron[3] (mg/l)	Est. Max. Instantaneous Surge[5] (GPM)	Horiz Perm (K md)
1	740	145	40	179	1050[4]	0.1[4]	0.08[4]	45	15
2	900	30	40	223	1050[4]	0.1[4]	0.08[4]	57	75
3	944	76	40	252	1050[4]	0.1[4]	0.08[4]	64	30
4	1094	26	62	306	540	12	1.2	120	130
5	1135	10	295	320	540	12	1.2	599	1600
6	1150	16	115	328	750	16	1.4	239	400
7	1222	25	330	361	704	16	1.4	756	725
8	1290	14	65	388	995	10	0.3	160	260
9	1393	57	265	442	645	19	1.0	743	260
10	1475	20	68	470	645	19	1.0	203	190
11	1506	14	53	482	581	17	1.0	162	210
12	1580	13	67	514	610	20	0.3	218	280
13	1632	21	32	538	720	20	0.2	109	85
14	1748	22	40	588	1400	24	1.1	149	100
15	1867	33	44	642	595	8.9	0.9	179	75
16	1975	25	63	687	1480	20	1.8	275	140
17	2016	24	240	705	1480	20	1.8	1073	550
18	2056	10	150	719	2500	45	0.9	684	825

1) As shown by the Pump/Spinner test of 5-4-77; all depths are measured from the kelly bushing

2) Computed from hydrostatic gradient to the midpoint of the aquifer from a static water level at 400 ft.

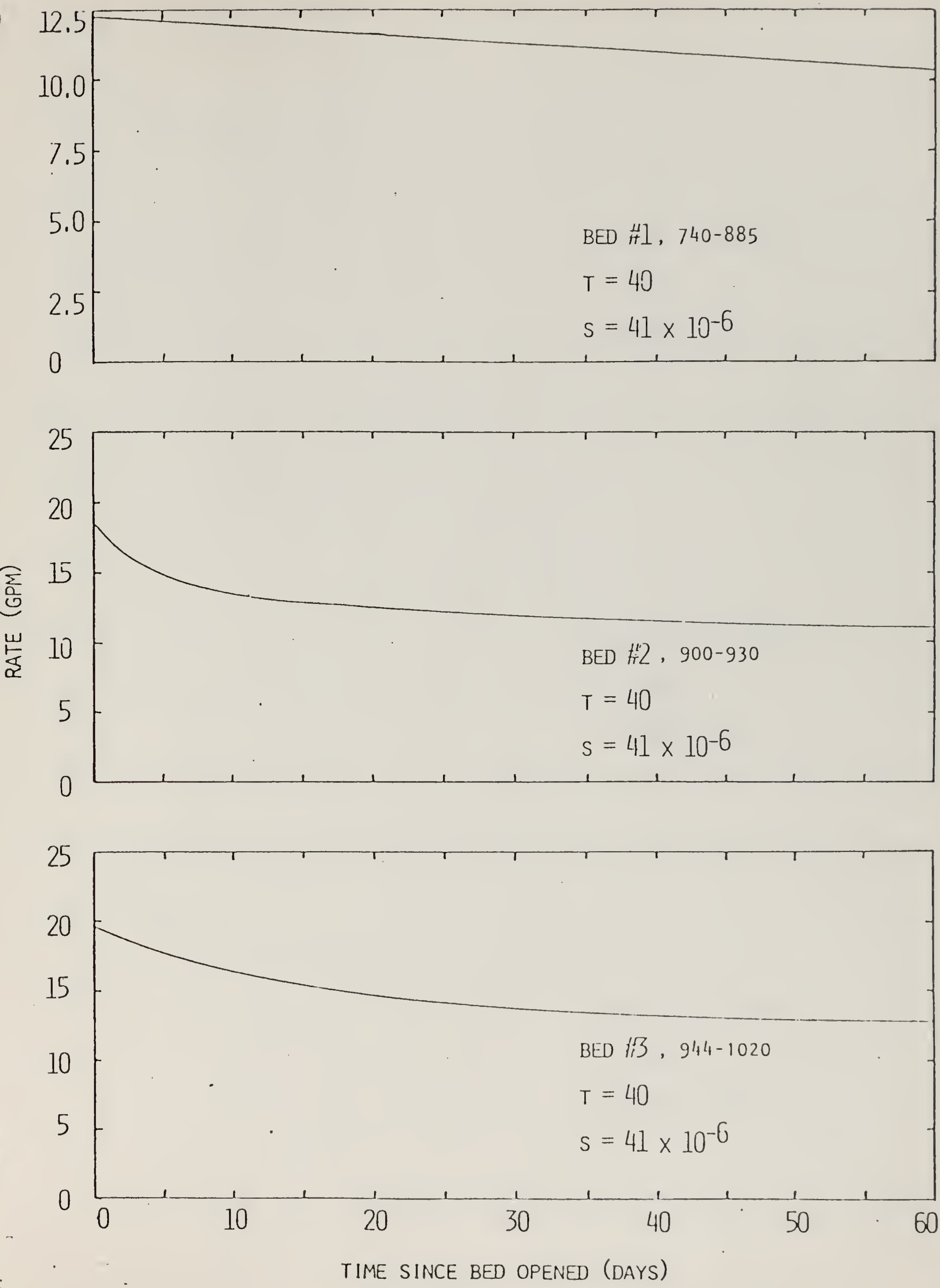
3) Based on stratigraphic correlation to the water samples taken during the drill-stem tests on SG-17

4) Based on the Uinta water sample from 33X-1

5) Computed at one-hour of drawdown using the Jacob and Lohman method for 29 to 34 ft. finished diameter shafts.

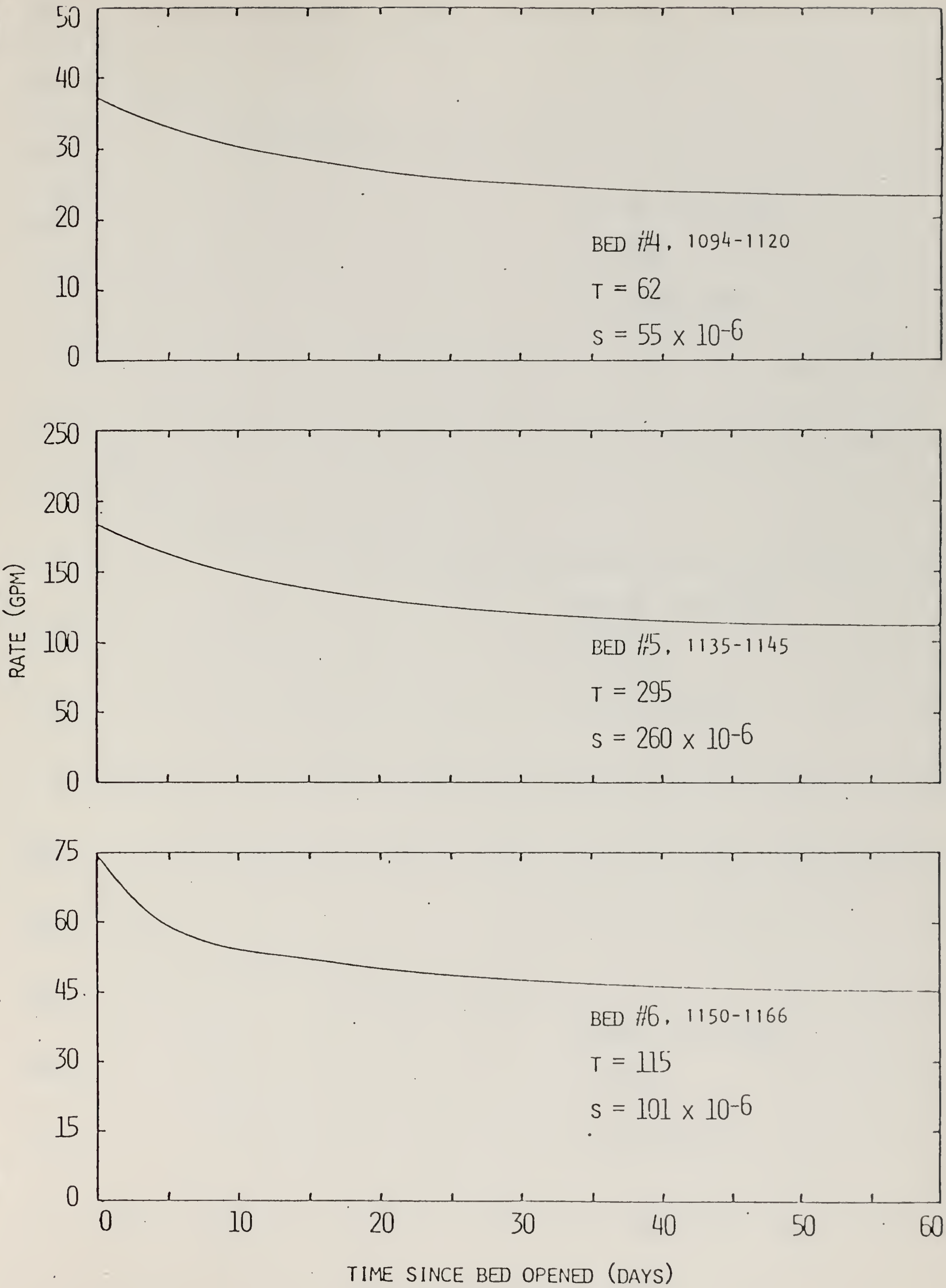
(EXPECTED ACCURACY: ± 50%)

BED #1 THROUGH #3



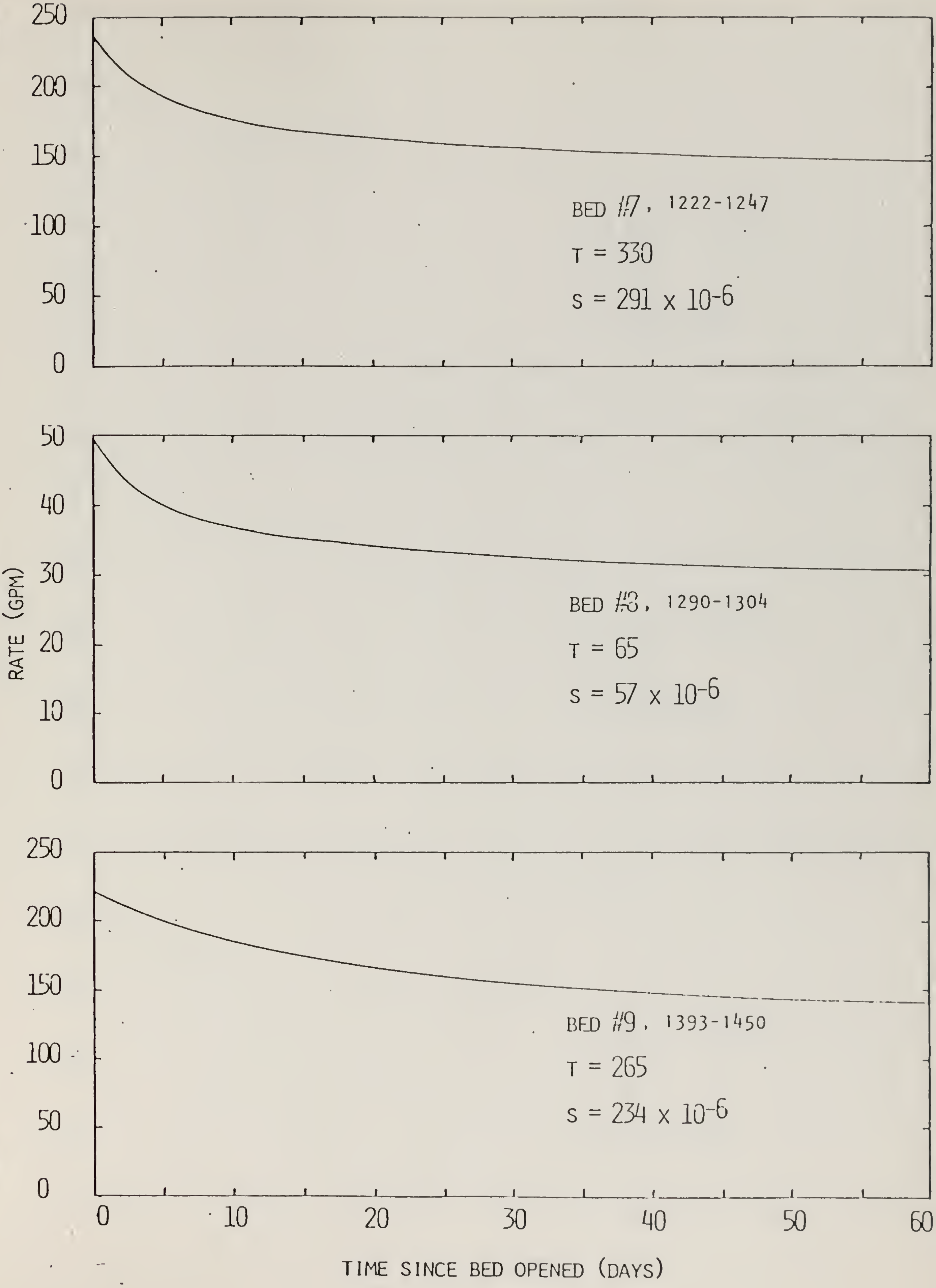
(EXPECTED ACCURACY: ± 50%)

BED #4 THROUGH #6



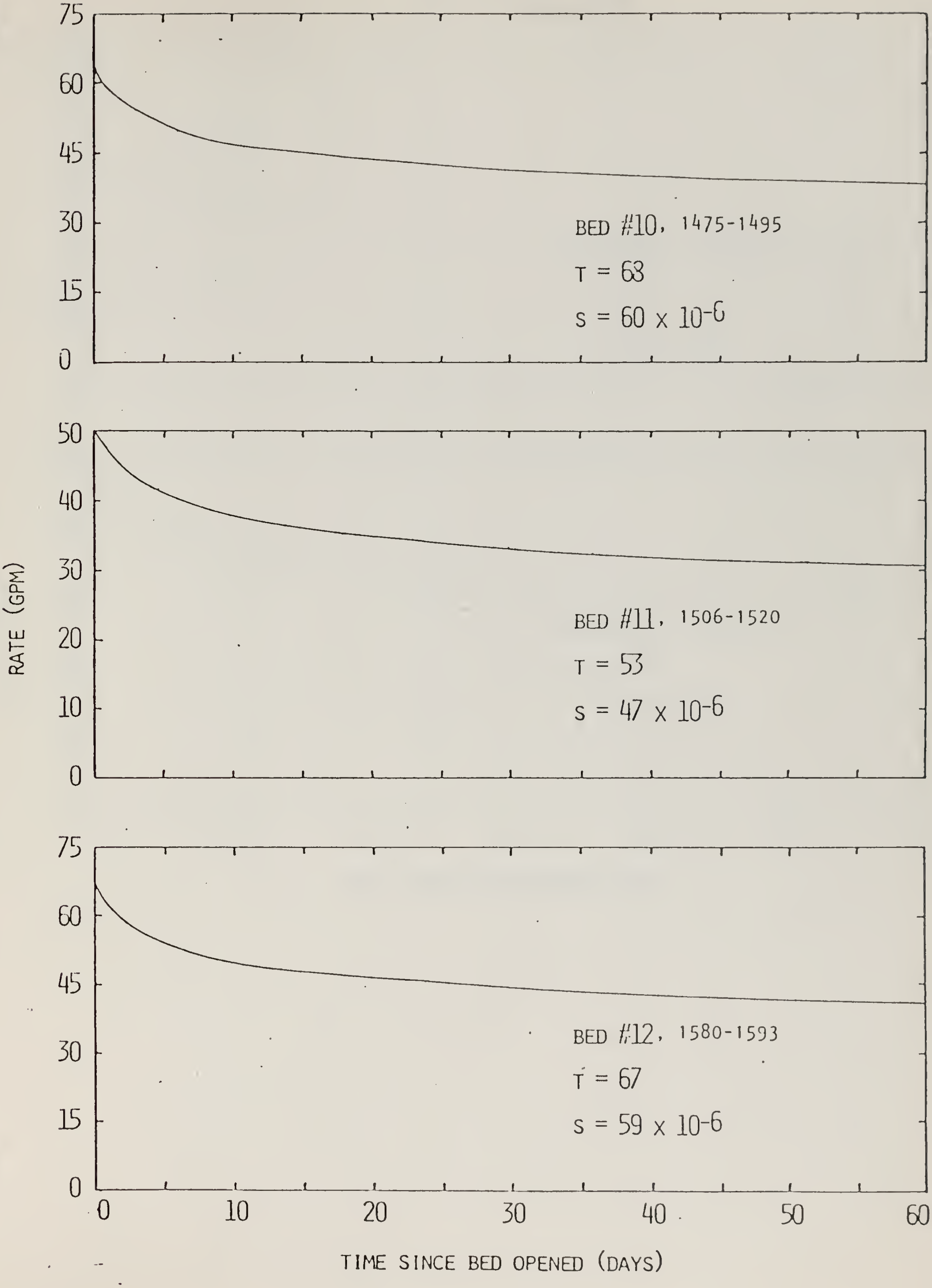
(EXPECTED ACCURACY: ± 50%)

BED #7 THROUGH #9



(EXPECTED ACCURACY: ± 50%)

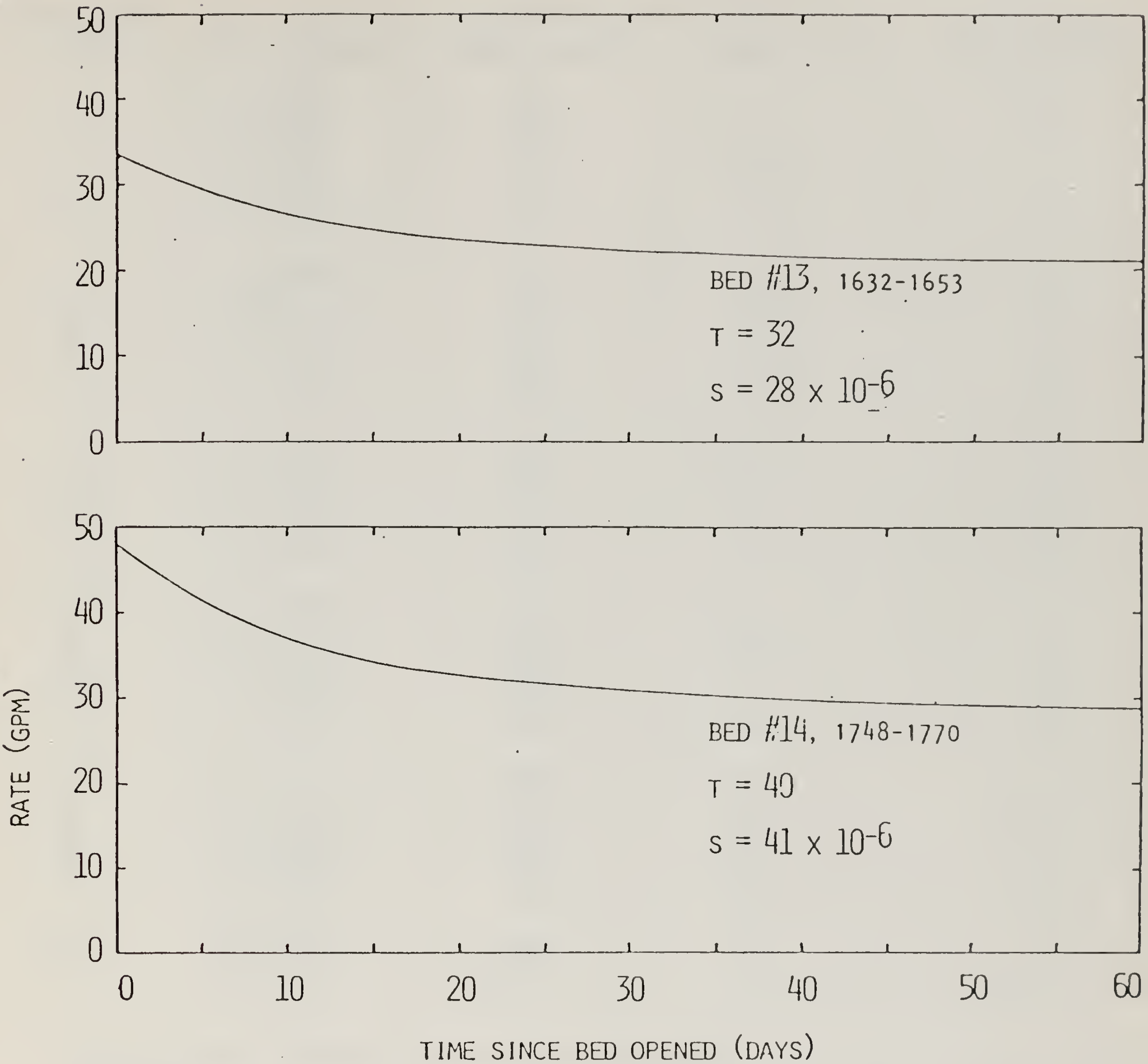
BED #10 THROUGH #12



BEST ESTIMATE FOR SHAFT INFLOW BY AQUIFER UNIT

(EXPECTED ACCURACY: ± 50%)

BED #13 THROGH #14



RESULTS OF WATER SAMPLE ANALYSES
FROM DRILL-STEM TESTS IN SG-17*

Drill Stem Test No.	Test Interval	Total Dissolved Solids (mg/l)	Fluoride Concentration (mg/l)	Boron Concentration (mg/l)
2	788-808	420	10	2.3
3	822-869	500	11	2.3
4	866-919	503	15.3	
5	919-970	564	13.5	
6	970-1017	600	12	2.0
7	1015-1062	540	12	1.2
8	1066-1117	750	16	1.4
9	1115-1166	704	16	
10	1164-1212	995	10	.3
11	1200-1224	980	10	.4
13	1224-1250	955	10	1.0
14	1250-1271	800	10	.2
15	1280-1309	680	18	1.8
17	1329-1374	735	10	.1
18	1374-1419	645	19	1.0
19	1423-1470	581	17	
21	1473-1522	610	20	.3
23	1514-1572	720	20	.2
24	1561-1622	800	20	.5
25	1618-1670	1150	25	1.4
26	1668-1720	1400	24	1.1
27	1711-1770	2175	25	1.1
28	1768-1820	2250	24	1.5
29	1818-1870	595	8.9	.9
30	1869-1920	1480	20	1.8
31	1918-1970	2500	45	.9
34	2120-2170	34,400	40	47.0

*Analysis Results Reported in Quarterly Data Release No. 2, Vol. 1, pp. IIB-53 through 59.

WATER QUALITY ANALYSIS
AQUIFER PUMP TESTS

UPPER MAIN AQUIFER PUMP TEST*

Well Number: AT-1

Date	9/15/74	10/22/74 (15 hours)	12/23/74		
Element Measured					
1. Aluminum (ug/l)		.04			
2. Ammonia (mg/l)		0.8			
3. Arsenic (ug/l)		.02			
4 Barium (ug/l)		.01			
5. Beryllium (ug/l)					
6. Bicarbonate (mg/l)	435	420	570		
7. Bismuth (ug/l)		<.005			
8. Boron (ug/l)		0.7	1.5		
9. Cadmium (ug/l)		<.005			
10. Calcium (mg/l)	40	61	16		
11. Carbonate (mg/l)		24	<.1		
12. Cerium (mg/l)		<.005			
13. Chloride (mg/l)	3	7	7		
14. Chrome, Hexavalent (mg/l)		<.01			
15. Cobalt (ug/l)		.001			
16. Conductivity, Specific (uv)	1050	990			
17. Copper (ug/l)		.02			
18. Fluoride (mg/l)	2.7	4.8	18		
19. Gallium (ug/l)		<.005			
20. Hardness, Total (mg/l)		180			
21. Hydroxide (mg/l)		<.1			
22. Iron (ug/l)		.4			
23. Lead (ug/l)		.01			
24. Lithium (ug/l)		.08			
25. Magnesium (mg/l)	34	7.9	9.5		
26. Manganese (ug/l)		.01			
27. Mercury (ug/l)		.0085			
28. Molybdenum (ug/l)		.005			
29. Nickel (ug/l)		.01			
30. Nitrate (mg/l)		1.0			
31. pH	8.2	8.4			
32. Phosphate, Total (mg/l)		<.1			
33. Potassium (mg/l)			<1		
34. Selenium (ug/l)		<.005			
35. Silica (mg/l)	19	18			
(*)36. Silver (ug/l)		<.005			
37. Sodium (mg/l)	194	210	200		
38. Solids, Dissolved (mg/l)	767	740	560		
39. Strontium (ug/l)		1			
40. Sulfate (mg/l)	261	210	<4		
41. Titanium (ug/l)		.1			
42. Vanadium (ug/l)		.001			
43. Yttrium (mg/l)		<.005			
44. Zinc (ug/l)		<.5			
45. Zirconium (ug/l)		<.005			
46. Radioactivity					
Gross Alpha (pcl)		4.2			
Radium 226*		.3			
Gross Beta (pcl)		0			
Thorium 230**					
Uranium**					
47. Total Organic Carbon (TOC)					
If TOC > 10 mg/l then measure					
Dissolved Organic Carbon		<1			
Suspended Organic Carbon					
Phenols					
Sulfur, Acid Extract					
Nitrogen, Base Extract					

(*) Not required

* Required if gross alpha is greater than 4 picocuries per liter (pcl).

** Required if gross beta is greater than 100 picocuries per liter (pcl).

*This page reproduced from Quarterly Summary Report #2

TABLE II B-30
GROUNDWATER ANALYSIS
LOWER AQUIFER PUMPING TEST AT-1

WATER QUALITY FROM LOWER MAIN AQUIFER PUMP TEST*

Well Number: AT-1
Location: SW¼ Sec. 7 T3S R96W

Depth: see footnotes
Elevation: 6909 G.L.

ELEMENT MEASURED--UNITS(mg/1) UNLESS NOTED	DATE ON WHICH SAMPLE TAKEN (a)	(b)	(c)		
1. Aluminum					
2. Ammonia (Nitrogen)					
3. Arsenic					
4. Barium					
5. Beryllium					
6. Bicarbonate	711	734	755		
7. Bismuth					
8. Boron	3	3	3		
9. Cadmium					
10. Calcium	4.2	3.8	3.8		
11. Carbonate	24	16	11		
12. Cerium					
13. Chloride	5	5	5		
14. Chrome, Hexavalent					
15. Cobalt					
16. Conductivity, Specific (μU/cc)	1120	1110	1110		
17. Copper					
18. Fluoride	19	19	19		
19. Gallium					
20. Hardness (mg/1 $CaCO_3$)	24	22	24		
21. Hydroxide					
22. Iron	0.6	<.05	<.05		
23. Lead					
24. Lithium	.05	.05	.04		
25. Magnesium	2.7	2.6	2.7		
26. Manganese					
27. Mercury					
28. Molybdenum					
29. Nickel					
30. Nitrate			.6		
31. pH	9.0	8.8	8.6		
32. Phosphate, Total	<.1	3	<.1		
33. Potassium	1	.9	.9		
34. Selenium					
35. Silica	13	13	13		
36. Sodium	320	310	310		
37. Solids, Dissolved	752	747	750		
38. Strontium					
39. Sulfate	12	8	12		
40. Titanium					
41. Vanadium					
42. Yttrium					
43. Zinc					
44. Zirconium					
45. Radioactivity					
Gross Alpha (pcl)					
Radium 226*					
Gross Beta (pcl)					
Thorium 230**					
Uranium **					
46. Total Organic Carbon (TOC)					
If TOC >10 mg/1 then measure					
Dissolved Organic Carbon					
Suspended Organic Carbon					
Phenols					
Sulfate, Acid Extraction					
Nitrogen, Base Extraction					
Polycyclic Aromatics					

* Required if gross alpha is greater than 4 picocuries per liter (pcl).
** Required if gross beta is greater than 100 picocuries per liter (pcl).

(a) jet test sample at 1700 ft. 1-28-75
(b) 3.5 hours of pumping at 1700 ft. 2-5-75
(c) 21 hours of pumping after restart 1700 ft. 2-16-75

*This page reproduced from Quarterly Summary Report #3

TABLE II B-31

FLUORIDE & BORON IN LOWER ZONE

AT-1 PUMPING TEST WATER

Date - 1975	1/20	2/5	2/23	2/24	2/25	2/27	2/28	3/1	3/3	3/5	3/7	3/19
Fluoride (ppm)	18.0	18.1	20.0	20.1	20.4	18.4	20.4	20.16	19.0	20.0	21.2	23.2
Boron (ppm)	0.65	0.88	1.15	1.10	1.13	1.2	1.6	1.42	2.58	2.02	2.18	2.00

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WATER QUALITY FROM MINI-PUMP TESTS*

TABLE II B-29
GROUNDWATER ANALYSIS
WATER FROM DRILLSTEM TESTS

Well Number: SG-1A
Location: SE¼ Sec. 2, T35 R97W

Depth: See Footnotes
Elevation: 6426

SAMPLES

ELEMENT MEASURED--UNITS(mg/l) UNLESS NOTED	(a)	(b)	(c)		
1. Aluminum					
2. Ammonia (Nitrogen)					
3. Arsenic					
4. Barium					
5. Beryllium					
6. Bicarbonate	1632	1127	1418		
7. Bismuth					
8. Boron	11	4	11		
9. Cadmium					
10. Calcium	5.2	4.8	6		
11. Carbonate	58	23	32		
12. Cerium					
13. Chloride	172	5	69		
14. Chrome, Hexavalent					
15. Cobalt					
16. Conductivity, Specific (μU/cc)	2750	1580	2200		
17. Copper					
18. Fluoride	19	20	17		
19. Gallium					
20. Hardness (mg/l $CaCO_3$)	40	32	38		
21. Hydroxide					
22. Iron	<.05	<.05	<.05		
23. Lead					
24. Lithium	.5	.1	.01		
25. Magnesium	5.5	3.4	5.2		
26. Manganese					
27. Mercury					
28. Molybdenum					
29. Nickel					
30. Nitrate	1.3	.9	.3		
31. pH	8.9	8.7	8.8		
32. Phosphate, Total					
33. Potassium	.3	1.3	2.4		
34. Selenium					
35. Silica	10	17	10		
36. Sodium	816	460	640		
37. Solids, Dissolved	1905	1103	1506		
38. Strontium					
39. Sulfate	8	12	19		
40. Titanium					
41. Vanadium					
42. Yttrium					
43. Zinc					
44. Zirconium					
45. Radioactivity					
Gross Alpha (pcl)					
Radium 226*					
Gross beta (pcl)					
Thorium 230**					
Uranium **					
46. Total Organic Carbon (TOC)					
If TOC >10 mg/l then measure					
Dissolved Organic Carbon					
Suspended Organic Carbon					
Phenols					
Sulfate, Acid Extraction					
Nitrogen, Base Extraction					
Polycyclic Aromatics					

* Required if gross alpha is greater than 4 picocuries per liter (pcl).
** Required if gross beta is greater than 100 picocuries per liter (pcl).

(a) DST 4 (909-938 feet)
(b) DST 8 (1125-1180 feet)
(c) DST 10 (968-1010 feet)

*This page reproduced from Quarterly Summary Report #3

GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 63005 RECORD # 59525

SAMPLE LOCATION: OCCY33X-1(C3-97-1)CADA
STATION ID: 394859108135100 LAT.LONG.SEQ.: 394859 1081351 00
DATE OF COLLECTION: BEGIN--770222 END-- TIME--2100
STATE CODE: 08 COUNTY CODE: 103 PROJECT IDENTIFICATION: 460806400
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 124UINT
COMMENTS:
COLL BY GJS

ALK,TOT (AS CACO3)	MG/L	530	MANGANESE DISSOLVED	UG/L	40
ALUMINUM DISSOLVED	UG/L	20	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	1	MOLYBDENUM DISSOLVED	UG/L	6
BARIUM DISSOLVED	UG/L	0	NO2+NO3 AS N DISS	MG/L	0.03
BICARBONATE	MG/L	650	PH FIELD		8.3
BORON DISSOLVED	UG/L	80	PHOS ORTHO DIS AS P	MG/L	0.05
BROMIDE	MG/L	0.1	PHOSPHATE DIS ORTHO	MG/L	0.15
CADMIUM DISSOLVED	UG/L	0	POTASSIUM DISS	MG/L	1.0
CALCIUM DISS	MG/L	89	RESIDUE DIS CALC SUM	MG/L	1050
CARBONATE	MG/L	0	RESIDUE DIS TON/AFT		1.43
CHLORIDE DISS	MG/L	13	SAR		2.0
COPPER DISSOLVED	UG/L	0	SELENIUM DISSOLVED	UG/L	0
DEPTH TOP OF SAM.FT.		67.0	SILICA DISSOLVED	MG/L	34
DPTH BOT. OF SAM.FT.		441.0	SODIUM DISS	MG/L	120
FLUORIDE DISS	MG/L	0.1	SODIUM PERCENT		28
HARDNESS NONCARB	MG/L	150	SP. CONDUCTANCE FLD		1550
HARDNESS TOTAL	MG/L	680	SP. CONDUCTANCE LAB		1530
IRON DISSOLVED	UG/L	40	STRONTIUM DISSOLVED	UG/L	5600
LEAD DISSOLVED	UG/L	1	SULFATE DISS	MG/L	360
LITHIUM DISSOLVED	UG/L	50	WATER TEMP (DEG C)		8.0
MAGNESIUM DISS	MG/L	110	ZINC DISSOLVED	UG/L	110

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/
CALCIUM DISS	89	4.442	BICARBONATE	650	10.6
MAGNESIUM DISS	110	9.049	CARBONATE	0	0.(
POTASSIUM DISS	1.0	0.026	CHLORIDE DISS	13	0.3
SODIUM DISS	120	5.220	FLUORIDE DISS	0.1	0.(
			SULFATE DISS	360	7.4
			NO2+NO3 AS N D	0.03	0.(
	TOTAL	18.735		TOTAL	18.

PERCENT DIFFERENCE = 0.57

CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 63006 RECORD # 59528

PLE LOCATION: OCCY 33X-1(C3-97-1 CADA)
.ATION ID: 394859108135100 LAT.LONG.SEQ.: 394859 1081351 00
DATE OF COLLECTION: BEGIN--770228 END-- TIME--1830
STATE CODE: 08 COUNTY CODE: 103 PROJECT IDENTIFICATION: 460806400
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 124GRRV
COMMENTS:
COLL BY GJS

ALK,TOT (AS CACO3)	MG/L	360	MANGANESE DISSOLVED	UG/L	10
ALUMINUM DISSOLVED	UG/L	20	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	7	MOLYBDENUM DISSOLVED	UG/L	11
BARIUM DISSOLVED	UG/L	200	NO2+NO3 AS N DISS	MG/L	0.01
BICARBONATE	MG/L	439	PH FIELD		8.3
BORON DISSOLVED	UG/L	190	PHOS ORTHO DIS AS P	MG/L	0.03
BROMIDE	MG/L	0.1	PHOSPHATE DIS ORTHO	MG/L	0.09
CADMIUM DISSOLVED	UG/L	0	POTASSIUM DISS	MG/L	0.3
CALCIUM DISS	MG/L	20	RESIDUE DIS CALC SUM	MG/L	627
CARBONATE	MG/L	0	RESIDUE DIS TON/AFT		0.85
CHLORIDE DISS	MG/L	6.2	SAR		6.7
COPPER DISSOLVED	UG/L	0	SELENIUM DISSOLVED	UG/L	1
DEPTH TOP OF SAM.FT.		67.0	SILICA DISSOLVED	MG/L	22
DPTH BOT. OF SAM.FT.		957.0	SODIUM DISS	MG/L	180
UORIDE DISS	MG/L	6.2	SODIUM PERCENT		74
RDNESS NONCARB	MG/L	0	SP. CONDUCTANCE FLD		945
HARDNESS TOTAL	MG/L	140	SP. CONDUCTANCE LAB		975
IRON DISSOLVED	UG/L	20	STRONTIUM DISSOLVED	UG/L	3700
LEAD DISSOLVED	UG/L	0	SULFATE DISS	MG/L	150
LITHIUM DISSOLVED	UG/L	40	WATER TEMP (DEG C)		15.5
MAGNESIUM DISS	MG/L	21	ZINC DISSOLVED	UG/L	60

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	20	0.998	BICARBONATE	439	7.196
MAGNESIUM DISS	21	1.728	CARBONATE	0	0.000
POTASSIUM DISS	0.3	0.008	CHLORIDE DISS	6.2	0.175
SODIUM DISS	180	7.830	FLUORIDE DISS	6.2	0.327
			SULFATE DISS	150	3.123
			NO2+NO3 AS N D	0.01	0.001
TOTAL		10.563	TOTAL		10.820

PERCENT DIFFERENCE = -1.20

GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 74024 RECORD # 60815

SAMPLE LOCATION: OCCY 33X-1(C3-97-1 CADA)
STATION ID: 394859108135100 LAT.LONG.SEQ.: 394859 1081351 00
DATE OF COLLECTION: BEGIN--770306 END-- TIME--1630
STATE CODE: 08 COUNTY CODE: 103 PROJECT IDENTIFICATION: 460806400
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 124GRRV
COMMENTS:
COLL BY SHS FOR GJS

ALK,TOT (AS CACO3)	MG/L	1130	MANGANESE DISSOLVED	UG/L	20
ALUMINUM DISSOLVED	UG/L	50	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	20	MOLYBDENUM DISSOLVED	UG/L	18
BARIUM DISSOLVED	UG/L	500	NO2+NO3 AS N DISS	MG/L	0.02
BICARBONATE	MG/L	1380	PH FIELD		8.2
BORON DISSOLVED	UG/L	760	PHOS ORTHO DIS AS P	MG/L	0.03
BROMIDE	MG/L	0.0	PHOSPHATE DIS ORTHO	MG/L	0.09
CADMIUM DISSOLVED	UG/L	1	POTASSIUM DISS	MG/L	0.9
CALCIUM DISS	MG/L	7.4	RESIDUE DIS CALC SUM	MG/L	1290
CARBONATE	MG/L	0	RESIDUE DIS TON/AFT		1.75
CHLORIDE DISS	MG/L	6.6	SAR		36
COPPER DISSOLVED	UG/L	1	SELENIUM DISSOLVED	UG/L	1
DEPTH TOP OF SAM.FT.		67.0	SILICA DISSOLVED	MG/L	9.9
DPTH BOT. OF SAM.FT.		1310	SODIUM DISS	MG/L	530
FLUORIDE DISS	MG/L	17	SODIUM PERCENT		96
HARDNESS NONCARB	MG/L	0	SP. CONDUCTANCE FLD		2070
HARDNESS TOTAL	MG/L	44	SP. CONDUCTANCE LAB		1940
IRON DISSOLVED	UG/L	70	STRONTIUM DISSOLVED	UG/L	1400
LEAD DISSOLVED	UG/L	6	SULFATE DISS	MG/L	24
LITHIUM DISSOLVED	UG/L	20	WATER TEMP (DEG C)		21.0
MAGNESIUM DISS	MG/L	5.7	ZINC DISSOLVED	UG/L	130

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	7.4	0.370	BICARBONATE	1380	22.619
MAGNESIUM DISS	5.7	0.469	CARBONATE	0	0.000
POTASSIUM DISS	0.9	0.024	CHLORIDE DISS	6.6	0.187
SODIUM DISS	530	23.055	FLUORIDE DISS	17	0.895
			SULFATE DISS	24	0.500
			NO2+NO3 AS N D	0.02	0.002
TOTAL		23.916	TOTAL		24.200

PERCENT DIFFERENCE = -0.59

GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 74025 RECORD # 60818

PLE LOCATION: OCCY 33X-1(C3-97-1 CADA)
STATION ID: 394859108135100 LAT.LONG.SEQ.: 394859 1081351 00
DATE OF COLLECTION: BEGIN--770311 END-- TIME--1430
STATE CODE: 08 COUNTY CODE: 103 PROJECT IDENTIFICATION: 460806400
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 124GRRV
COMMENTS:
COLL BY GJS

ALK,TOT (AS CACO3)	MG/L	1050	MANGANESE DISSOLVED	UG/L	10
ALUMINUM DISSOLVED	UG/L	50	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	30	MOLYBDENUM DISSOLVED	UG/L	47
BARIUM DISSOLVED	UG/L	600	NO2+NO3 AS N DISS	MG/L	0.01
BICARBONATE	MG/L	1280	PH FIELD		8.3
BORON DISSOLVED	UG/L	780	PHOS ORTHO DIS AS P	MG/L	0.04
BROMIDE	MG/L	0.0	PHOSPHATE DIS ORTHO	MG/L	0.12
CADMIUM DISSOLVED	UG/L	0	POTASSIUM DISS	MG/L	0.9
CALCIUM DISS	MG/L	11	RESIDUE DIS CALC SUM	MG/L	1240
CARBONATE	MG/L	0	RESIDUE DIS TON/AFT		1.69
CHLORIDE DISS	MG/L	7.9	SAR		27
COPPER DISSOLVED	UG/L	4	SELENIUM DISSOLVED	UG/L	3
DEPTH TOP OF SAM.FT.		67.0	SILICA DISSOLVED	MG/L	11
DPTH BOT. OF SAM.FT.		1621	SODIUM DISS	MG/L	500
ORIDE DISS	MG/L	15	SODIUM PERCENT		94
DNESS NONCARB	MG/L	0	SP. CONDUCTANCE FLD		1950
HARDNESS TOTAL	MG/L	70	SP. CONDUCTANCE LAB		1850
IRON DISSOLVED	UG/L	430	STRONTIUM DISSOLVED	UG/L	2100
LEAD DISSOLVED	UG/L	4	SULFATE DISS	MG/L	54
LITHIUM DISSOLVED	UG/L	30	WATER TEMP (DEG C)		21.0
MAGNESIUM DISS	MG/L	9.7	ZINC DISSOLVED	UG/L	90

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	11	0.549	BICARBONATE	1280	20.980
MAGNESIUM DISS	9.7	0.798	CARBONATE	0	0.000
POTASSIUM DISS	0.9	0.024	CHLORIDE DISS	7.9	0.223
SODIUM DISS	500	21.750	FLUORIDE DISS	15	0.790
			SULFATE DISS	54	1.125
			NO2+NO3 AS N D	0.01	0.001
	TOTAL	23.120		TOTAL	23.117

PERCENT DIFFERENCE = 0.01

GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 81021 RECORD # 62013

SAMPLE LOCATION: UCCY33X-1(C3-97-1)CADA
STATION ID: 394859108135100 LAT.LONG.SEQ.: 394859 1081351 00
DATE OF COLLECTION: BEGIN--770317 END-- TIME--0800
STATE CODE: 08 COUNTY CODE: 103 PROJECT IDENTIFICATION: 460806400
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 124GRRV
COMMENTS:
COLL BY GJS

ALK,TOT (AS CACO3)	MG/L	2060	MANGANESE DISSOLVED	UG/L	30
ALUMINUM DISSOLVED	UG/L	680	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	25	MOLYBDENUM DISSOLVED	UG/L	2
BARIUM DISSOLVED	UG/L	1200	NITROGEN NH4 ASN DIS	MG/L	28
BICARBONATE	MG/L	2510	NO2+NO3 AS N DISS	MG/L	0.02
BORON DISSOLVED	UG/L	1000	PH FIELD		7.4
BROMIDE	MG/L	0.2	PHOS ORTHO DIS AS P	MG/L	0.04
CADMIUM DISSOLVED	UG/L	0	PHOSPHATE DIS ORTHO	MG/L	0.12
CALCIUM DISS	MG/L	11	POTASSIUM DISS	MG/L	2.5
CARBONATE	MG/L	0	RESIDUE DIS CALC SUM	MG/L	2360
CHLORIDE DISS	MG/L	32	RESIDUE DIS TON/AFT		3.21
COPPER DISSOLVED	UG/L	1	SAR		51
DEPTH TOP OF SAM.FT.		67.0	SELENIUM DISSOLVED	UG/L	2
DPTH BOT. OF SAM.FT.		2078	SILICA DISSOLVED	MG/L	14
FLUORIDE DISS	MG/L	24	SODIUM DISS	MG/L	1000
HARDNESS NONCARB	MG/L	0	SODIUM PERCENT		97
HARDNESS TOTAL	MG/L	75	SP. CONDUCTANCE FLD		3900
IRON DISSOLVED	UG/L	190	SP. CONDUCTANCE LAB		4040
LEAD DISSOLVED	UG/L	0	STRONTIUM DISSOLVED	UG/L	830
LITHIUM DISSOLVED	UG/L	50	SULFATE DISS	MG/L	21
MAGNESIUM DISS	MG/L	11	WATER TEMP (DEG C)		29.0
			ZINC DISSOLVED	UG/L	10

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L
CALCIUM DISS	11	0.549	BICARBONATE	2510	41.13
MAGNESIUM DISS	11	0.905	CARBONATE	0	0.00
POTASSIUM DISS	2.5	0.064	CHLORIDE DISS	32	0.90
SODIUM DISS	1000	43.500	FLUORIDE DISS	24	1.26
			SULFATE DISS	21	0.43
			NO2+NO3 AS N D	0.02	0.00
TOTAL		45.018	TOTAL		43.74

PERCENT DIFFERENCE = 1.44

ENERGY
CONSULTING ASSOCIATES

TO: J.J. Hill

FROM: D.O. Cox

DATE: June 9, 1977

SUBJECT: Vertical Permeabilities

Per our conversation earlier this afternoon, I am sending you the Summary of Vertical Permeability Estimates, Tract C-b. This enclosed table is as complete as I could make it on short notice; I do not believe any prominent estimates of vertical permeability have been excluded.

Dave O. Cox

DOC/vpm
Enclosure

cc: R.E. Thomason ✓

817 SEVENTEENTH STREET SUITE 610 DENVER, COLORADO 80202 (303)623-8706

ZONE OR TEST	VERTICAL CONDUCTIVITY (10^{-3} ft/day)	VERTICAL PERMEABILITY (md)	ASSUMED THICKNESS (ft)	REFF
Mahogany	1.35	0.5	100	USGS Pg.
MIN-10	0.27	0.1	3	Quar Pg.
UMAPT	0.426	0.155	100*	Quar Pg.
	0.156	0.057	100*	
	0.123	0.045	100*	
	0.0805	0.029	100*	
	0.127	0.046	100*	
	0.0426	0.016	100*	
	0.0590	0.022	100*	
LMAPT	1.96	0.715	100*	
	0.0393	0.014	100*	
	0.0877	0.032	100*	
	0.0877	0.032	100*	
	0.344	0.125	100*	
	0.688	0.251	100*	
MIN-4	0.00160	0.00058	5	Qu Pg
MIN-6	4.55	1.66	6	
MIN-8	0.00306	0.00116	6	
MIN-10	0.278	0.101	6	
Mahogany	<0.0005	<0.00018	78	Qu Pg
MIN-4	0.685	0.25	5*	Go
MIN-6	0.493	0.18	6*	
MIN-8	1.645	0.6	6*	
MIN-10	0.658	0.24	6*	
DST-8	1447 (1154)	528 (421)		Go
DST-9	710 (2012)	253 (734)		
DST-11	3380 (15,872)	1233 (5790)		
DST-12	2231 (1480)	814 (540)		
DST-15	--- (258)	--- (94)		
DST-17	7388 (20,526)	2695 (7488)		
DST-18	7895 (13,684)	2880 (4992)		
DST-20	732 (5598)	267 (2042)		
DST 1-1	<274 (4660)	<100 (1700)		G
1-2	5208? (60)	1900? (22)		
1-3	112 (<2.7)	41 (< 1)		
	41 (<2.7)	15 (< 1)		
1-4	<2.7 (?)	<1 (?)		
2-2	47 (8770?)	17 (3200?)		
3-2	<2.7 (?)	<1 (?)		
3-3	(2.7?)	(1?)		
3-4	<2.7 (?)	<1 (?)		
3-5	<2.7	<1		
3-6	16 (3.6)	6 (1.3)		

ASSUMED THICKNESS (ft)	REFERENCE	COMMENTS
100	USGS Professional Paper 908 Pg. 66	Based on numerical simulation between the upper and lower aquifers
3	Quarterly Summary Report #3 Pg. 73	Based on finite element simulation
100*	Quarterly Summary Report #4 Pg. 61	Based on Leaky Aquifer Type Curve Matching AT-1a
100*		AT-1b
100*		AT-1c
100*		AT-1d
100*		SG-6
100*		SG-10a
100*		SG-11
100*		AT-1c (#1)
100*		AT-1c (#2)
100*		AT-1d
100*		SG-6 (#1)
100*		SG-6 (#2)
100*		SG-10
5	Quarterly Summary Report #4 Pg. 65	
6		
78	Quarterly Summary Report #8 Pg. 17	Based on Krishnamurthi modelling of UMAPT using the method of Neuman and Witherspoon
5*	Golder, Vol. IIIA, pg. 2-31	Based on Leaky Aquifer Type Curve Matching
5*		
5*		
6*		
	Golder, Vol. IIIA, pg. 2-55	Method of interpretation obscure; values given are for annulus injection (stem injection) results
	Golder, Vol. IIIA, pg. 2-83	Multipacker tests; interpreted with finite element method simulation; values given are k_{va-1} (k_{v1-2})

SUMMARY OF VERTICAL PERMEABILITY ESTIMATES - TRACT C-b / PAGE

ZONE OR TEST	VERTICAL CONDUCTIVITY (10^{-3} ft/day)	VERTICAL PERMEABILITY (md)	ASSUMED THICKNESS (ft)	REFERENCE
Uinta	93	34	580	Golder, Vol.
Pentz	2.7	1	100	
Upper Prolific	8.2	3	275	
Mahogany	0.3	0.1	45	
Lower Prolific	58	21	120	
Leached Zone	8.2	3	560	
MIN-4	<0.2	<.05	5	ECA Subsurfac
MIN-6	0.6	.2	6	Tract C-b, Ta
MIN-8	< 0.06	<.02	6	
MIN-10	0.6	.2	6	
Mahogany	<.01	<.004	78	ECA, Unpublis

*Assumed for purposes of this table - no thickness reported by reference

ASSUMED THICKNESS (ft)	REFERENCE	COMMENTS
580 100 275 45 120 560	Golder, Vol. IIIA, pg. 6-4	Values used in modelling; based on subjective picture of aquifer system and numerical simulation of the infiltration hump on the tract
5 6 6 6	ECA Subsurface Hydrology Tract C-b, Table 1	Based on Leaky Aquifer Type curve analysis; all values are order of magnitude estimates
78	ECA, Unpublished	Based on analytic multilayer modelling of UMAPT

eference

2.1.3

ENERGY
CONSULTING ASSOCIATES

MEMORANDUM

TO: J.J. Hill

FROM: D.O. Cox

Date: June 9, 1977

Subject: Hydrology

Per our discussion June 7, I am transmitting the estimates of permeability for wells 32X-12 and 33X-1 by zone. The aquifer numbering follows that established in our letter of May 19.

The assigned permeabilities have been computed from the transmissivities and thicknesses estimated from the pump/spinner tests in early May.

Dave O. Cox

Enclosure
DOC/vpm
cc: R.E. Thomason

C-b Tract Well 32X-12

Aquifer No.	Assigned Permeability (md)
1	15
2	75
3	30
4	130
5	1600
6	400
7	725
8	260
9	260
10	190
11	210
12	280
13	85
14	100
15	75
16	140
17	550
18	825

C-b Tract Well 33X-1

Aquifer No.	Assigned Permeability (md)
1	?
2	?
3	?
4	90
5	130
6	260
7	80
8	550
9	190
10	140
11	260
12	75
13	75
14	100
15	100
16	710
17	250

HEALTH AND SAFETY PROGRAM - OUTLINE

1. SAFETY PROGRAM AND PERSONNEL
   MEDICAL FACILITIES
2. GROUND CONTROL
   FIRE PREVENTION AND CONTROL
   MINE VENTILATION
3. MAN HOISTING
   EMERGENCY PROCEDURES AND ESCAPEWAYS
   ELECTRICAL
4. EXPLOSIVES
   HAULAGE AND DRILLING EQUIPMENT
   VARIANCES AND PERMITS

RMP

SAFETY PROGRAM AND PERSONNEL

A. PERSONNEL

1. SAFETY MANAGER
2. SAFETY INSPECTORS - ONE PER SHIFT
3. E.M.T. - EIGHT PER SHIFT

B. INSPECTION AND MONITORING - REGULAR SAFETY INSPECTIONS AND MONITORING OF SAFETY PROGRAM

C. PROGRAM

1. DAILY SAFETY CONTACTS
2. WEEKLY CREW MEETINGS
3. MONTHLY DEPARTMENT MEETINGS
4. MONTHLY SUPERVISORS SAFETY MEETINGS

MEDICAL FACILITIES

A. AMBULANCES - SURFACE

1. THREE FULLY EQUIPPED AMBULANCES
2. AIR AMBULANCE SERVICE TO GRAND JUNCTION AND/OR DENVER

B. AMBULANCES — UNDERGROUND

C. FIRST AID ROOMS — UNDERGROUND

D. EMERGENCY ROOM — SURFACE

RMP

GROUND CONTROL

A. SIZE AND LOCATION OF OPENINGS
B. NUMBER OF RETORT DRIFTS AND LEVELS
C. GROUND STABILIZATION

FIRE PREVENTION AND CONTROL

A. MOBILE FIRE FIGHTING EQUIPMENT - SURFACE
B. UNDERGROUND DIESEL AND ELECTRICAL EQUIPMENT
C. CONVEYOR BELTS BOTH SURFACE AND UNDERGROUND
D. UNDERGROUND FIRE WATER SYSTEM
E. FIRE EXTINGUISHER PROGRAM
F. FIRE BRIGADE BOTH SURFACE AND UNDERGROUND

MINE VENTILATION

A. FACE AIR QUANTITIES
B. FACE AIR QUALITY
C. PROCESS GAS CONTROL

MAN HOISTING

EMERGENCY MINE EVACUATION PROCEDURES

A. ESTABLISH MINE EVACUATION PLAN
B. WARNING SYSTEMS
C. EDUCATION AND TRAINING
D. REFUGE CHAMBERS
E. MINE RESCUE TEAMS

ELECTRICAL

A. INSTALLATION PER NATIONAL ELECTRICAL CODE
B. PERMISSIBLE EQUIPMENT
C. SPECIAL PROCEDURE

RMP

EXPLOSIVES

A. TYPE OF EXPLOSIVE
B. STORAGE FACILITIES
C. TRANSPORTATION

HAULAGE AND DRILLING EQUIPMENT

A. CONTROL OF DIESEL EXHAUST
B. ROLLOVER PROTECTION AND FIRE SUPPRESSION
C. VENTILATION
D. CONVEYOR BELTS
E. FUEL STORAGE AND DISPENSING AREAS

VARIANCES AND PERMITS

I. Safety and Health Program - C-b Site

The program of Safety and Health of the employees at the C-b site will be one that will comply with all Federal and State Safety and Health standards as per the Federal Metal and Nonmetal Mine Safety Act administered by the Mine Enforcement and Safety Administration (MESA), and as per Bulletin 20 administered by the Colorado Division of Mines. Local and Company (Occidental) health and safety requirements will also be an intregal part of the program.

Health studies will be conducted and kept up-to-date in the interest of the health conditions of the employee that may be encountered in the development of the oil shale industry.

A. Personnel - Following are staff levels required for the peak level of the permanent work force.

1. Safety Manager - overall direction of Health and Safety Program.
2. Safety Inspectors and inspector for industrial hygiene, dust control, noise control, and toxic gas control. Technicians, clerks, and other required personnel will be in the department.
3. E.M.T.'s - at lease 8 qualified E.M.T.'s per shift.
4. Safety Training Supervision for all safety requirements will be kept current.

B. Inspection and Monitoring will comply with all Federal, State, local and company Health and Safety regulations.

C. Program

1. Daily safety contacts/between Supervisor and employees.
2. Weekly crew safety meetings/between Supervisor and employees. Generally five to ten minute meetings on a specific subject.
3. Monthly department meetings - Monthly meeting of entire operating department personnel. Meeting conducted by department head and supervisors.
4. Monthly supervisors safety meeting - Monthly safety meeting of plant supervisory staff.
5. Monthly manager-employee safety committee meetings.

II. Medical Facilities - Commercial Phase

A.

1. Ambulance - Surface - Three fully equipped gasoline powered ambulances to transport injured personnel to hospitals in Rifle or Meeker.
2. Air ambulance service for more critically injured personnel to Grand Junction and/or Denver.

B. Ambulance - Underground - One fully equipped diesel powered ambulance on each level of the mine. These ambulances can be hoisted to the surface if the need arises.

C. First Aid Rooms - Underground - Each level of the mine will have at least one fully equipped first aid room for initial treatment.

professionally staffed emergency room. This facility will be equipped comparable to a larger hospital such as Grand Junction. Full time staff one/two doctors and ten nurses.

III. Health Program

A. Industrial Hygienist will supervise program.

B. Dust, toxic fumes, diesel exhaust for air quality will be periodically monitored for control of environment as per Federal and State requirements.

C. Noise Control: measurements and feasible engineering studies.

D. Hearing Conservation Program.

E. Respirator program.

F. Carcinogen Control Studies program. In off-gases, process water and product oil.

IV. Ground Control (Maintaining a safe back and ribs)

Drift size, especially height, has influence on use of rock bolts to safely control the back.

Based on ground conditions, procedures for ground stabilization and types of support will be developed and selected. Rock support systems such as resin rock bolts, grouted bolts, conventional bolts, shot crete, etc. will be investigated to determine the best system.

V. Fire Prevention and Control

A. Mobile fire fighting equipment and for surface complete hydrant and turbet nozzle layout will be provided.

B. Underground mobile and stationary diesel operated equipment and some electrical equipment will have automatic fire suppression systems and carbon monoxide monitors.

C. Conveyor belts will be flame resistant belting and have automatic fire suppression systems at specific points.

D. Underground fire water system will be provided.

E. Fire extinguisher program will include hand operated dry chemical, mobile foam and dry powder combination units. Foam units will be provided for process oil installations.

F. Organization of underground fire brigade made up of self-contained oxygen breathing units, including trained personnel will be available on all levels and on surface.

VI. Mine Ventilation

A. Adequate ventilation control will be provided for all working areas.

The ventilation requirement for diesel operated equipment is 75 c.f.m./ horsepower. Ventilation in excess of this flow will be provided. 100 ft/min vel. of air in all headings will be provided for dust control, etc.

B. Dust suppression and control through use of water and chemicals will be provided. A stringent air sampling program will be employed as noted in Section III.

C. Process gas control: continuous sampling of areas by monitors for toxic gases and retort pressures will occur.

VII. Man Hoisting - Hoisting standards apply to those hoists and appurtenances used for hoisting men, but where men are endangered by hoisting rock or material, the appropriate safety guidelines will be used. Many new requirements for installation, maintenance and operation of hoisting equipment have been established through promulgated safety standards. Close safety monitoring will be required. Regular inspections will be made and records kept. Automatic hoists will be in full compliance with all safety standards.

VIII. Emergency Mine Evacuation Procedures and Escapeways

A. Establish and keep current a plan of mine evacuation through current and marked escapeways.

B. Install Stench Warning System through ventilation systems and air lines.

C. Educate and train employees in mine evacuation and procedure.

D. Refuge chamber will be in place while second openings or escapeways are developed.

E. Ample, appropriate oxygen breathing apparatus will be maintained and crews trained for emergency purposes on all levels and on the surface.

IX. Electrical Equipment

A. All electrical equipment will be installed, maintained, and used to conform to the National Electrical Code.

B. Permissible electrical equipment will be required in special restricted areas, i.e. process gas and oil control machinery.

C. Special underground and retort equipment repair procedures will be used by maintenance and repair personnel.

X. Explosives (Blasting Agents)

A. The type of explosives used depends upon the retort configuration. Large volumes can possibly be mixed at the hole similar to larger open pit mines. (However, safe handling equipment shall be developed and a variance applied for from standard 57.6 - 220 which states ammonium nitrate fuel oil blasting agents shall not be mixed underground.)

B. Storage facilities will be controlled according to the type of stringent control for explosives or blasting agents used.

C. Close control of transportation, storage, and use shall be required at all times.

XI. Haulage and Drilling Equipment

A. Diesel fumes shall be strictly controlled through use of scrubbers.

B. Roll over protection and fire suppression systems shall be installed on all diesel operated mobile equipment.

C. Ventilation requirements in all headings shall meet all requirements for gases and fume control.

D. Conveyor belts underground shall be closely controlled for safety.

E. Underground fuel storage and dispensing areas are possible but will require special permits for large quantities of diesel fuel.

XII. Variances and Permits

A. Variances from safety standards to permit use of fire underground to store larger quantities of diesel fuel underground, and to allow increased hoisting speeds will be required and closely monitored.

An efficient health program and an effective safety program will require more components than are in the above listings. The listings are general outlines. Additional attention will be included in day-to-day safety programs. Accepted principles of accident prevention have been adopted by Occidental Oil Shale, Incorporated, and these principles shall be adhered to by all personnel. Included as an exhibit is a copy of "Safety Rules!! Oil Shale Modified In Situ Mining and Retorting Operations" of Occidental Oil Shale, Inc./Colorado.

C·b Shale Oil Venture

2372 G Road — P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

July 8, 1977

RECEIVED
JUL 11 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S.G.S.

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
U.S.G.S. Conservation Division
Mesa Federal Savings & Loan
131 N. 6th, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

The attached summary report from R. D. Ridley is for your information. It is in response to your questions concerning the shipping/market alternatives available for shale oil production occurring during the ancillary phase of Tract development. Production from the two retort cluster will occur mostly in the first three quarters of 1981. Production from the four retort cluster will occur mainly in the first three quarters of 1982. As such production during this phase will not be continuous or at a constant level. The level of production and total quantity also depends on the retort design finally selected.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason

R. E. Thomason
Manager, Leasehold Development

RET:pmr

Attch.

cc: R. D. Ridley
R. A. Loucks
R. J. Fernandes

OXY INTER-OFFICE MEMORANDUM

JUL 8 REC'D

TO: Bob Thomason

DATE: July 6, 1977

FROM: RDR R. D. Ridley

COUNTRY:

SUBJECT: Oil Production from Ancillary Facilities

We have conducted several marketing studies through Purvin & Gertz and are in a position to project where oil shipments will ultimately go from the C-b operation; however, we did not consider production from an ancillary facility in these studies. Our present thoughts are that this oil will be marketed by one of several alternatives.

One of the significant markets for shale oil is the refining market in the Salt Lake City area. Chevron has a pipeline from Rangely to Salt Lake with an estimated spare capacity of at least 25,000 barrels per day; therefore, one alternative is the trucking of oil from the C-b site to Rangely to be placed in the pipeline for shipment to Salt Lake City. The route from the C-b site would be down the Piceance Creek road to the highway at White River and then west to Rangely.

A second alternative is the shipment of oil by unit or tank train from the Rifle area. The Denver and Rio Grande Railroad has sidings at Rifle and 7.1 miles east at the town of Silt. They do not anticipate any difficulty in making a siding available to handle at least 5 or 6 cars at a time, but might have to add trackage for greater shipments. If this alternative is chosen, the oil would then be shipped by truck from the C-b site to Rio Blanco and then from Rio Blanco to Rifle or Silt. From this loading point the oil could be shipped west to Salt Lake City or east to a variety of locations.

A third alternative being considered is the trucking of the oil to a point along the Marathon (Platte) Pipeline -- possibly at Casper, Wyoming. The oil will be placed in storage there until sufficient size batches are accumulated to pipe the oil through that system to markets in the Midwest. Marathon's system terminates at Wood River, Illinois, while oil can be shipped by other pipelines from there to other points in the Midwest.

I hope this will answer your question from the Department of Interior. At this point we are not envisioning any pipeline construction in relation to shipping the oil from the C-b site for the ancillary production. In order to calculate the number of trucks that will be used to take the oil offsite, you can assume the capacity of each truck at 160 barrels. The tank train or unit train capacity is 23,800 gallons per car, or 567 barrels.

RDR:ca

cc: Bob Fernandes
Bob Loucks
George Ogden

POST-OPERATIONS
(Abandonment Plan)

Because the shale oil complex is expected to have an operating life of about 60 years, it is difficult to predict at this time the disposition of the facility after the recoverable oil shale reserves beneath the Tract have been depleted. The disposition of the complex at that time will depend upon a variety of factors including:

- the future profitability of shale oil and associated secondary products.
- potential changes or modifications to current retorting technology.
- the feasibility of retorting the shale from the Tract's zones, below the L-4 zone.
- the value of the complex to other reserve holders.
- the extent of the oil shale industry at that time.

Alternate methods of disposal may include a sale of the facility, or dismantling the facility. Because of the range of possibilities, it would be misleading to state that any particular alternative is viewed as more probable than the others at this time.

If the plant complex is sold and the buyer assumes the Lease obligations, the Lessee would seek to obligate the buyer to assume responsibility for maintaining the raw shale embankment and catchment dams. Assuming that the plant is not sold, the Lessee has developed plans for dismantling the facilities. These plans, in general, will apply equally to any early or planned termination or completion of the project, insofar as activity to the date of termination requires specific decommissioning procedures. Specific plans for decommissioning each component of the plant are summarized below.

1. Surface and Underground Facilities

After the operation of the facility is terminated, a multi-phase rehabilitation program will be implemented. The first phase will be to remove salable items. All vessels, pumps, compressors, aboveground pipe, structural steel facilities, steel tanks, building, and other salable items will also be disassembled and removed from the site. The disposition of roads, in particular paved roads, will be resolved with the Federal, State and local authorities to the point that they might serve future area use. This may involve sale or dedication and release to other authorities.

Non-salvageable items remaining after the first phase will be knocked down and broken up during the second phase. Block or concrete buildings and concrete structures will be broken up and leveled close to grade. High concrete structures and foundations will be topped off. All hard-surface paving such as asphalt or concrete will be broken up in place. Underground pipes and culverts will be flushed, drained and plugged, and left in place. Hoisting equipment and head frames will be dismantled and removed from the Tract. The mine shafts will be backfilled as necessary to secure them safely. The areas will be graded and revegetated to conform with surrounding terrain.

Underground works and retired retorts will be stabilized. Depending on the management technique developed to accomplish groundwater quality stability, the underground workings may eventually be allowed to refill with water.

The third phase will consist of earth-moving operations. Earth will be removed from the fill area at the facility site. All foundations, knocked-down concrete rubble, and broken-up paved areas will be covered with a plant growth medium to create a proper root zone for vegetation and to prevent subsequent weathering from uncovering rubble piles. After being broken up, paving will be covered over with at least one foot of earth. Treatment ponds and ditches will be filled. The earthen dikes surrounding tanks will be leveled. Benches, sidehill cuts and fills will be smoothed out or filled in to create a contour effect. The facing of reinforced-earth retaining walls will be removed. Concrete retaining walls will be demolished. Knolls will be rounded and sidehill slopes will be graded to appear much like the adjacent natural terrain.

The last phase will be revegetation. During the earthwork phase, the ground will be slightly furrowed or ponded to capture natural precipitation. The regraded surfaces will be covered with a plant growth medium.

2. Conveying and Material Handling Facilities

All mechanical items will be removed from the Tract. Buildings will be demolished and leveled to existing grade level. Concrete structures and storage silos will be demolished and leveled. Earth moving will be performed to return the graded areas as close to their original contours as practicable. The conveyor belt foundations will be covered with earth. Roads will be broken up and covered with earth, the side ditches will be filled and the landscape will be rounded. The rubble piles created by knocking down buildings and silos will be dispersed, covered with 18 inches of plant growth medium and the fill rounded to conform with the terrain. This fill will probably come from the original disturbed site. Areas receiving fill will be revegetated.

3. Off-tract Facilities

Buildings, tanks, high pressure vessels, utilities, pipeways, loading racks, railroad spurs and other off-tract facilities will either be sold in accordance with mine supervisor's approval or dismantled and everything above grade will be removed from the site. Foundations will be knocked down. Asphalt roads and railroad road beds will be obliterated, regraded and revegetated.

Underground piping inside the facilities will be flushed, drained and plugged, and left in place. The underground pipelines from the plant will be plugged at each end and left in place. A plant growth medium from the original area will be spread over the facilities site and the area will be revegetated with proven plant materials for this specific site.

4. Off-tract Water Diversion Facilities

All facilities will either be sold in accordance with the mining supervisor's approval or removed, including the river water intake structure, low-head and high-head pumps, grit chamber, settling basins, buildings, fencing and access roads. After removal of all equipment and structures, the site will be restored as nearly as practicable to its previous condition. The underground lines will be plugged and left in place. It should be understood that this post operation may not coincide with other post operations because water augmentation may continue for some time after termination of the oil shale recovery operation.

5. Roads

Roads sold or not turned over to other jurisdictional authorities will be rehabilitated by the removal of asphalt, any gravel surfacing, retaining structures, culverts, drainage structures, guard rails, signs and other structures, and then graded to restore natural drainage patterns and revegetated.

6. Dams

There is a substantial possibility that the Lessee may sell or turn over the dams to the government or to local conservation or industrial interests. If the dams are not released, the Lessee will either leave the dams as permanent drainage control structures, in accordance with appropriate government approvals and permits, or the dam site will be reclaimed as discussed below.

Exposed metal work will be removed and salvaged. The concrete and rock fill material used for construction of the dams will be excavated, placed and compacted at the borrow area or removed to the disposal area if there is an excess. The embankment material will be excavated only to the original ground line so that a smooth transition from natural ground to the ground under and behind the dams is provided. Spillway areas will be replaced with rock and fill material removed from the dam. Even though this replaced material is to be compacted, it is anticipated that because of swelling, excess material will remain. This excess material will be graded to contours that will blend with adjacent undisturbed areas. Regraded areas will be sloped to the drainages. Roads used during the operation of the dams and those developed for removal of the dams will be obliterated by recontouring.

All graded areas and areas changed by construction activities will be restored as nearly as possible to their original condition. All vestiges of construction within the project area will be removed so that the project area can be restored to near its original condition. The regraded area will then be revegetated.

7. Raw-Shale Embankment

Lessee will develop a revegetated, stable surface on the raw-shale embankment which will be as resistant to local forces of weathering and erosion as is the surrounding soil. Under these circumstances, it will not be necessary to develop a permanent maintenance plan for the embankment. If for any reason longer maintenance is required, permanent maintenance plans or alternate disposal methods will be implemented as appropriate. Details of raw shale revegetation are discussed in Erosion Control and Rehabilitation Plan, III.E. Areas with coarse rock fill, concrete and asphalt rubble will also follow this plan.

8. Revegetation

All disturbed surface areas other than those described above (7. Raw-shale Embankment) will be revegetated in accordance with the general procedures described in Erosion Control and Rehabilitation Plan, III.D.

9. Post Operations Monitoring

According to conditions existing at the time operations are completed and any trends established by the operations monitoring data, monitoring will continue in particularly sensitive areas. The post operations monitoring plans will be determined just ahead of that time in accordance with annual analysis of sensitive monitoring data and mining supervisor's recommendations.

RETORT STABILIZATION

The stabilization of retorts following completion of their production phase will be a regularly occurring activity. The production plan will be further refined to optimize utilization of gases and heat which continue after oil production is completed. These gases will continue to vent into the gas system, will be utilized and treated in the normal course of operations. The main environmental concern is the relationship of spent shale contained in the retired retorts and the aquifer system which the retort intersects.

An investigation has been designed to determine the effect of spent shale contact on water quality and to be able to predict the resulting potential for change in the quality of groundwater. Results of this investigation integrated with other background monitoring data on ground water, mineralogy of spent shale, rock mechanics and subsidence will be design engineering criteria for the stabilization management employed. Stabilization management may involve removal of water for a period of time, quality monitoring, and treatment to upgrade the quality to a level suitable for discharge. Allowing retorts to refill, or planned refilling with water and subsequent holding will be considered, and the hydrologic effects will be studied.

Retort leaching investigations are being implemented on the D.A. Shale site in order to develop data and criteria for control design. As mentioned previously, the objectives of this investigation are:

1. To determine the effect of spent shale contact on ground water.
2. To predict the quality of resulting groundwater.

The method is:

1. To establish background data on spent shale
2. To introduce water of known quality into the spent retort at a known rate
3. To monitor effluent water quantity and quality
4. The investigation will be continued for sufficient time in order to identify change trends and will eventually continue on the C-b Tract.

The results expected are:

To be able to show which constituents are leached and the time relationship.

With regard to retort stabilization and abandonment, we reaffirm our position as responsible leaseholders to conduct all operations in an environmentally sensitive manner. This means that whenever operations are permanently or temporarily discontinued, works and facilities at the surface and below will be secured in a way sensitive to the ecosystem, safety, and the rights of others. Actions and works involved would depend on the permanence and time element of the discontinuance of operations.

A permanent abandonment would involve the following:

A. Offer the facility to the Lessor under the terms of the lease. If the Lessor exercises this option, no further action on the part of the Lessee will be required.

B. Should the Lessor not exercise the option, the following actions would take place:

   1. Permanent removal or safeguarding of all buildings and structures

2. Secure mine openings and underground workings so that no hazards exist.
3. Secure and safeguard all dams and ponds.
4. Remove all product from storage tanks and pipelines.
5. Flush and plug all underground pipelines.
6. Reclaim all disturbed areas according to the Erosion Control and Rehabilitation Plan.
7. Underground works and retired retorts will be stabilized. Depending on the management technique developed to accomplish groundwater quality stability, the underground workings may eventually be allowed to refill with water.

According to conditions existing at the time of abandonment and any trends established by the operations monitoring data, monitoring will continue following abandonment in particularly sensitive areas. The post-abandonment monitoring plans will be determined at the time.

U. S. DEPARTMENT OF THE INTERIOR

PROTOTYPE OIL SHALE LEASING PROGRAM

AIR QUALITY CONTROL PLAN FOR TRACT C-b

Submitted to:

Peter A. Rutledge
Area Oil Shale Supervisor

By:

C-b Shale Oil Venture

Ashland Oil, Inc.
Occidental Oil Shale, Inc., Operator

July 21, 1977

AIR QUALITY CONTROL PLAN

Page No.

App. A - Air Quality Control Plan for Tract C-b (Supplementary Information). June 10, 1977

App. B - Air Quality Control for Oil Shale Tract C-b (Supplementary Information). November 1, 1976

LIST OF TABLES

AIR QUALITY CONTROL PLAN

1. INTRODUCTION

This air quality control plan is presented in two phases: The ancillary phase and commercial operations. This is entirely appropriate since 1) permits to construct are expected to be issued for each of these two phases, 2) more details are known at the present time for the earlier ancillary phase, and 3) improved rough-terrain air diffusion models and their inputs will exist at a later date to provide refined estimates for full-scale operations.

The control plan consists of an emission inventory by operational activity along with controls descriptions and efficiencies, citations of appropriate emission and ambient-air-quality standards, and demonstration of compliance by means of diffusion modeling.

Pollution sources can be categorized as point, line or area sources. Examples of these are: a stack; a line of traffic; and acreage of shale-storage piles. Process emission stacks are planned emission sources; leakages from storage tank domes, dust from unpaved roads and shale piles are defined as "fugitive". Sources can be on-tract or off-tract. The control plan recognizes and discusses these source types.

Before proceeding to a description of pollution control measures it should be noted that tall stacks will be used (except for dust originating at ground level) to effectively disperse the pollutants. Diffusion is usually enhanced in rough terrain, typified by the C-b site.

The numbers (sizes, flows, etc.) presented in this report are nominal values utilized in the modeling of the ancillary phase as presented to the Area Oil Shale Supervisor on June 2, 1977, representing the best estimates available as of that date. This material supplements that contained in Modifications to the Detailed Development Plan as submitted by the Lessees to the Area Oil Supervisor in February, 1977.

2. CONTROL PLAN FOR THE SHAFT-SINKING AND ANCILLARY-DEVELOPMENT PHASES

2.1 Emissions Inventory

2.1.1 Shaft-Sinking Phase

In the shaft-sinking phase, seven activities are delineated as potential pollution sources in the emissions inventory on Table 2.1.1. These include: 1) access road; 2) temporary power generation: 3) site preparation; 4) mine shaft-shale transfer point; 5) transfer via diesel equipment; 6) shale crushing; 7) shale disposal. Dust is the sole pollutant considered in items 1), 3), 4), 6) and 7).

2.1.1.1 Access Road

The main access road adjoins the preferred off-tract primary road corridor, as described in Modifications to the Detailed Development Plan (hereafter abbreviated MDDP), Section III. D.5. Approximate on-tract location is shown on Figure I-A in the MDDP. Appendix B presents the emission factor for unpaved roads (Pedco Report #9) as

$$\text{Emission factor (lbs/veh. mi)} = 0.27\,(1.068)^{v} + 1.54$$

where v = vehicle speed (MPH).

Assuming a peak loading of 967 workers per shift in 2-man car pools with 50% shift overlap, there are 726 cars on the 4.2 mile access road for 0.21 hour at 20 mph. The above emission factor yields 2.5 lbs dust/vehicle-mile which translates into 36,300 lbs dust/hour over this time interval. The conclusion is that the major access road must be paved.

2.1.1.2 Temporary Power Generation

In the early stages of the shaft-sinking phase, permanent power of the magnitude required is not available at the site. A combined bank of generator sets of approximately 10000 hp (7460 kw), equivalent to 6.10×10^{8} BTU on a 24-hour basis, will be used. Utilizing EPA Document AP-42 for fuel oil with 0.023% sulfur, expected emissions in lbs/day are: particulates 36.7, SO_2 12.2 and NO_2 513. No controls are required, so long as each generator in the bank is under 1000 hp and the bank is unmanifolded.

2.1.1.3 Site Preparation

Figure III-A of the MDDP shows the location of the ancillary facilities at the three sites described on Page III-7:

Site	Acreage Disturbed
General Facilities Site	8
Gas Treatment Facilities	3
Steam Generation Facilities	3
TOTAL	14

From a fugitive dust standpoint, it is assumed that 25% of this total acreage is "exposed" at any one time. At an emission factor of 1.4 tons/ac/mo (EPA AP-42) and utilizing chemical stablizers to achieve 80% control efficiency, the resulting emission rate is 2.7 lbs/hr.

TABLE 2.1-1

EST[illegible]SSIONS INVENTORY DURING SHAFT - SINKING AND ANCILLARY DEVELOPMENT PHASES

PHASE	SOURCE OR ACTIVITY	MATERIAL HANDLING RATE	POLLUTANT	EMISSION FACTOR W/O CONTROL		EMISSIONS W/O CONTROL (lb/hr)	CONTROL MEASURE		EMISSIONS WITH CONTROL		STACK CHARACTERISTICS				
							DEVICE	EFFICIENCY (%)	(lb/hr)	ppm (1)	NUMBER	HEIGHT (m)	DIAM. (m)	VOL. FLOW (SCFM)	EXIT TEMP. [illegible]
SITE PREPARATION & SHAFT SINKING	Access Road	[illegible] 2 [illegible]; 2[illegible] mph; 3049 veh. [illegible]	Fugitive Dust	0.27 (1.068)^{v} + 1.54 where v = veh speed (mph)	(b)	36320 lb/hr	Pave Road	100	0						
	Temporary Power Generation	10,000 [illegible]	Particulates SO_2 NO_x	36.7 lb/day (0.02%S) 12.2 lb/day 513 lb/day	(a)	1.5 0.5 21.4	Unmanifolded - No Control	0 0 0	1.5 0.5 21.4		10	[illegible]	0.5		
	Site Preparation	14 acres Disturbed (25% Exposed)	Dust	1.4 tons/ac/mo	(a)	13.6	Chemical Stabilizers	80	2.7						
	Mine Shaft Shale Transfer Pts.	9400 tons/day	Dust	0.1 lb/ton	(d)	39.2	Wet Suppression	75	9.8						
	Surface Transfers via Diesel Equipment	Total Surface Diesel - 4000 gal/day 9400 tons shale/day 400 veh mi/day - shale tr	Particulates SO_2 CO THC NO_x Fugitive Dust	13 lb/1000 gal (0.02%S) 2.7 lb/1000 gal 225 lb/1000 gal 37 lb/1000 gal 370 lb/1000 gal 1000 lb/day	(a) (b)	2.2 0.5 37.5 6.2 61.7 41.7	Catalytic Converter " " Chemical Stabilizers	0 0 90 90 0 80	2.2 0.5 3.8 0.6 61.7 8.3						
	Shale Crushing	9400 tons/day	Dust	0.5 lb/ton	(c)	195.8	Baghouse	99	2.0		1	10	0.6	20000	Ambient
	Shale Disposal	9400 tons/day - 80 acres max.	Dust	8 tons/ac/yr	(b)	145.0	Chemical Stabilizers	80	29.2						
ANCILLARY DEVELOPMENT PHASE	[illegible] - (Total including Mi[illegible], Blasting, Handling & Hauling, Crushing, and Rubbling)	± 1 blast/shift; ± 70 times/year Diesel 7000 gal/day; 41000 tons shale/day	Part. 24 hr Annual SO_2 - 3 hr - 24 hr Annual CO - 1 hr 8 hr Annual THC - 3 hr Annual NO_x - Annual	See Table 2.1-2 for Emission sub-totals by activity and Table 2.1-3 for Emission Factors		1600 1500 45 7 2 300	Baghouse Baghouse Diesel Equipment has Catalytic Converters for CO, HC	99 99 0 0 0 90 90 90 90 90 0	16 15 45 7 2 19140 2450 257 59 12 300	5.5 5.1 7.0 1.1 0.3 6791 869 91 2.9 0.6 64.8	1	88	3.3	636,534	>3° Above Ambient
	In-Situ Gas Treatment	10% Full Scale - assumed in modeling [illegible] BTU/SCF (HHV)	Particulates SO_2 CO THC NO_x	1.17 lb/10[illegible] ft^3 1500 ppm [illegible] S equiv. 1.33 lb/10[illegible] ft^3 0.234 lb/10[illegible] ft^3 9.36 lb/10[illegible] ft^3	(a) (a)	7.4 1500 ppm[illegible]S [illegible] 1.5 59	Stretford Unit Followed by Thermal Oxidizer	0 99 0 0 0	7.4 17.4 8.4 1.5 59	6.5 7.2 7.9 0.2 33.6	1	25	[illegible]	240,000	400
	Steam Generator - (Boiler)	620 bbl/day fuel oil, [illegible],000 lb/day boiler	Particulates SO_2 CO THC NO_x	0.023% Sulfur Fuel Oil, Non-Sulfur estimates from burning fuel oil	(a)	16.3 3.6 [illegible].3 3.3 67	No Emission Controls	0 0 0 0 0	16.3 3.6 4.3 3.3 87	114.3 11.8 32.3 3.5 397	1	52	1.6	30,070	400
	Fuel Tank Storage	3.99 × 10[illegible] gal/5 days 10% Full Scale Handling	THC (Fugitive)	Storage Loss: 0.0052 lb/d[illegible] per 1000 gal Work Loss: 1 lb/gal	(a)		Floating Roof Tanks		11						
	Mine Shaft - Conveyor Transfer Pt.	41000 tons/day	Dust	0.1 lb/ton	(d)	170.8	Wet Scrubber	99	1.7		1	10	1.2	90,000	Ambient
	Shale Conveyor	41000 tons/day	Dust	0.03 lb/ton	(d)	51.3	Continuous Wet Suppression and Chemical Addit.	85	7.7						
	Shale Disposal	41000 ton/day, 80 ac. max.	Dust	2 tons/ac/yr	(b)	146	Chemical Stabilizers	80	29.2						

(a) EPA AP-42 (b) Pedco Rest #9 (c) Marshall and Agapito, Colony App 14 (d) Assumption

(1) ppmv except for particulates which are ppmw

2.1.1.4 Mine Shaft - Shale Transfer Points

In this phase shale rock is transported from 5 shafts to the disposal area by truck:

Shaft	Total Sinking Time	Span
12' D Vent/Escape Shaft	15 mo.	'78 - Mid '79
34' D Production Shaft	17 mo.	'78 - Mid '79
34' D Service Shaft	17 mo.	'78 - Mid '79
6' D Tem. Gas Shaft	5 mo.	Sept.'79 - '80

A total of 16 million tons of rock from shaft sinking is removed up to the start of commercial operations on September 1, 1982 (i.e. over a 56-month span) for an average daily tonnage of 9400 tons/day.

An emission factor of 0.1 lb of dust per ton of shale rock has been assumed; wet suppression techniques with an efficiency of 75% reduce these emissions to 9.8 lbs/hr.

2.1.1.5 Surface Transfers via Diesel Equipment

These include transfers of shale rock from the hoists at the shaft transfer points and general on-tract usage of diesel equipment for transportation, hauling, grading, etc. Approximately 4000 gal/day of diesel fuel are estimated for average surface usage.

EPA AP-42 has been utilized to estimate the emission factors listed in Table 2.1-1. Catalytic convertors with 90% efficiency reduce both CO and THC emissions. Sulfur content of the diesel fuel is assumed to be 0.02%.

Approximately 400 vehicle miles per day are estimated solely for transport of shale to the disposal area; this yields 1000 lb/day of fugitive dust, or 41.7 lbs/hour. Application of chemical stablizers on a regular basis results in 80% control and reduces fugitive emissions to 8.3 lbs/hour.

2.1.1.6 Shale Crushing

The surface crusher provides both construction fill at 6-12 inches in diameter and fill for Cottonwood Gulch. Marshall and Agapeto in Appendix 14 of the Colony Environmental Impact Statement estimated the dust from crushing to be 0.5 lbs/ton. At 9400 tons per day, this amounts to 195.8 lbs/hour. A baghouse collection device with 99% efficiency will reduce emissions to 2.0 lbs/hour. These emissions exit through a 10 meter stack.

2.1.1.7 Shale Disposal

Emission factors for uncontrolled shale acreage have been estimated from Pedco Report #9 as 8 tons/acre/year. This reference also cites 50% control achieved through twice-per-day watering and 80% control through application of chemical stabilizers.

Appendix A yielded the result that approximately 80 acres of shale disposal chemically treated could comply with air pollution standards. Thus it is tentatively planned that no more than 80 acres will be unrevegetated at any one time; this corresponds to an emission rate of 29.2 lbs/hr with 80% control. More refined estimates of emission factors for raw shale utilizing alternative

controls coupled with further work on vegetation techniques are warranted here inasmuch as fugitive dust from the raw shale pile proved to be one of the critical items from the initial modeling results. The sensitivity of allowable shale disposal acreage to emissions from the pile is as follows: -33 acres/ton/acre/year emission. (This is read as "a decrease of 33 acres of unrevegetated shale is required for each ton per acre per year that emissions from the shale pile increase".) This points up the desirability of improving the accuracy of the emissions estimate.

It should be noted that fugitive dust on the Tract tends to be large particles. Generally such particle size is not associated with potential health hazards or diminished visibility.

2.1.2 Ancillary Development Phase

This plan and associated modeling assume that the ancillary-phase processing rate is 10% of full-scale operations or 5700 bbl/day. The mine is assumed to be operating at the full-scale rate of 41,000 tons of mined-out shale per day.

This plan includes full-scale development mining under ancillary development. In the development mining phase material produced during development of stations, access ways, service areas, and during the initial retort development will be crushed underground and transported to the 12' diameter shaft.

The emissions inventory for the ancillary phase is shown on Table 2.1-1. It includes the following sources or activities: 1) mine vent, 2) in-situ gas treatment, 3) steam generator, 4) fuel tank storage, 5) mine shaft-conveyor transfer point, 6) shale conveyor, and 7) shale disposal.

2.1.2.1 Mine Vent

The mine ventilation system requires an airflow of 636,534 scfm and utilizes a stack 88 meters in height. The height is constrained to be (approximately 10 feet) higher than the mine hoist-house for worker health and safety protection while working at the top of the hoist-house. Such height coupled with the large momentum flux of the mine-vent exhaust plume enhances plume diffusion in the atmosphere.

As described in the MDDP (Page III-26) the mining cycle in conventional room and pillar mining consists of drilling, charging the drilled face, blasting, wetting the blasted rock pile, loading, hauling, scaling and roof bolting.

The nominal rubbled-column retorts are 200 x 200 feet in plan and 310 feet in height. Only sufficient shale will be removed from within the retort volume to provide an approximate 20% to 25% void which redistributes by rubblizing with conventional explosives to provide a uniformly bulked-full retort column.

This control plan identifies emissions from mining operations which flow through the mine vent stack as: "mining", blasting, handling and hauling by use of underground diesel equipment, crushing, and rubblizing.

Table 2.1-1 shows the total emissions from the mine vent by pollutant. Blasting is expected to occur during shift changes, and its emissions are highly time dependent. They are presented for averaging times corresponding to air quality regulations; annual, 24-hour, 8-hour, 3-hour, and 1-hour. More detail regarding mine vent emissions is presented on Table 2.1-2. Emission-factor-related assumptions are presented on Table 2.1-3. Eighty percent control of the particulates produced in the mine is achieved by a combination of wet suppression

TABLE 2.1-2

MINE VENT EMISSIONS, LB/HR.

Pollutant	Avg. Time	Mining, Blasting, Hauling, Crushing	Rubbling	Diesel Equipment	Total
Particulates	24-hour	10.3	1.4	3.8	15.5
	Annual	10.3	0.3	3.8	14.4
SO_2	3-hour	0.1	43.3	0.08	45
	24-hour	0.03	5.4	0.08	7
	Annual	0.03	1.1	0.08	2.0
CO	1-hour	274	18,800	65.6	19,140
	8-hour	34.3	2,350	65.6	2,450
	Annual	34.3	157	65.6	257
THC	3-hour	0.7	47	10.8	58.5
	Annual	0.3	1.2	10.8	12.3
NO_x	Annual	34.3	157	108.2	299.5

TABLE [illegible]-3

MINING EMISSION-FACTOR-RELATED ASSUMPTIONS

1) Rubbling is assumed to occur not more than once per 24-hour period and not more than 70 times per year.

2) It is assumed that 7,000 gallons of diesel fuel are burned underground daily. Diesel emissions are estimated from EPA AP-42, p. 3.1.5-2 and appear in Table 2.1-1 per 1000 gallons under "Surface transfers via diesel equipment". Diesel equipment use catalytic convertors.

3) Crushing is estimated to produce 0.5 lb. of particulates/ton of shale blasted; see EPA AP-42, Table 8-20.1. Blasting is estimated to produce no more particulates than crushing. Handling and hauling are estimated to produce no more particulates than two pounds per ton. Eighty per cent of the particulates produced are assumed to settle out in the mine (EPA AP-42). Collection effeciency of the balance is estimated at 99%. Five per cent of the particulates formed in rubbling are assumed to escape from the retort into the mine.

4) ANFO utilizing 6% fuel oil is assumed to be the explosive used in mining and rubbling. Fuel oil with 0.023% sulfur is assumed.

5) Blasting is assumed to produce 0.04 lb. of CO and 0.04 lb. of NO_2 per lb. of ANFO, due to non-ideal reaction behavior. Rubbling produces 18,800 lb. of CO once every 5 days.

6) It is assumed that 0.5% of the fuel oil in ANFO is not burned in blasting and comes out in the mine vent as hydrocarbons.

techniques and ordinary settling by the baffling provided by the multiplicity of rooms and passages. The SO_2 in the ventilation air is controlled solely by selection of 0.02% low-sulfur fuels. The noxious gases produced from periodic blasting (at shift change) will be exhausted without control; their dispersion from the tall stack is more than adequate to keep ground level concentrations well below those required by air quality standards.

2.1.2.2 In-Situ Gas Treatment

The retort offgas is treated to remove sulfur compounds before it is thermally oxidized. The assumption is made here, subject to detailed study at a later date, that organic sulfur compounds are sufficiently low in concentrations that they do not have to be removed. A Stretford or similar process is utilized to remove hydrogen sulfide down to a level that the overall sulfur content is not greater than 15 ppmv equivalent H_2S as the nominal design. Two design alternatives are presented in Sections 2.4.1 and 2.4.2. Inasmuch as H_2S levels are in the neighborhood of 1500 ppmv to the Stretford unit, this represents a control efficiency of 99%.

Burning the retort offgas will convert carbon monoxide and hydrocarbons to carbon dioxide and water. Particulates will be at very low levels. Residual sulfur compounds (i.e. after the removal process described above) will be converted to sulfur dioxide. Oxides of nitrogen will be kept to a minimum utilizing low burner temperatures and excess air. All pollutants will thus be at sufficiently low levels that they can be adequately dispersed by exhausting through a tall stack.

Non-sulfur pollutants in burned offgas were estimated as follows: An analysis of the fuel content of the offgas showed it to be essentially gaseous hydrocarbons. The overall carbon-to-hydrogen mole ratio is approximately 3 : 7, which compares with that of a mixture of half propane (C_3H_8) and half propylene (C_3H_6). Emission factors for gaseous fuels of this type are estimated by EPA ratioing the emission factors for natural gas and the fuel in question against their higher heating values (EPA AP-42, March 1975, pg. 1.5-2). This procedure was used for the offgas. The emission factors for natural gas were taken from page 1.4-2 of EPA AP-42, March 1975. The higher heating value for natural gas was taken as 1050 BTU/scf and the higher heating value from the offgas was taken as 81.9 BTU/scf.

2.1.2.3 Steam-Generating Facilities

The 100,000 lbs/day boiler in the ancillary phase burns very low sulfur fuel oil (<0.023% by weight); in the full-scale operations it will burn offgas. Boiler flue gas is exhausted through a relatively tall stack without treatment. Estimates of the non-sulfur emissions have been obtained from EPA AP-42, (Table 1.3-1) as 16.3, 4.3, 3.3, and 87 lbs/hour for particulates, CO, THC and NO_x respectively.

Burned retort offgas and boiler exhausts will be hot (ca. 400°F). Thus, plume rises from their respective stacks will be significant.

2.1.2.4 Fuel Tank Storage

Fugitive hydrocarbon losses are expected from floating-roof fuel tank storage. The figures for losses from "tank storage" also include

losses from handling product oil, whether stored or not. Full scale storage is assumed to be five days' production; storage in the ancillary phase is assumed to be 1/3 full scale. Handling capacity is assumed to be 10% of full scale. Hydrocarbon losses from storage are assumed to be equivalent to a distillate fuel and estimated to be 0.0052 lb/day/1000 gal.; working losses are estimated to be 1.0 lb/1000 gal. throughput (EPA AP-42, pp. 4.3-8,9).

2.1.2.5 Mine Shaft-Conveyor Transfer Point

The 12' ventilation/escape shaft is also used as a temporary ore production shaft in the ancillary phase. In this mode, it is equipped with a headframe, double drum hoist and a ladderway with landings. Shale is transported up the shaft and transferred to a surface conveyor belt. An emission factor of 0.1 lb. of dust per ton of shale has been assumed. A wet scrubbing device with a 99% efficiency reduces emissions from 170.8 lb/hr to 1.7 lb/hr.

2.1.2.6 Shale Conveyor

The 41,000 tons per day of mined-out shale are transported from the mine transfer point to the shale disposal area via conveyor belt. Emissions are estimated to be 0.03 lbs. of dust/ton of shale transported. Continuously applied wet suppression techniques (with chemical additives, if required) are assumed to achieve 85% control in reducing emissions from 51.3 to 7.7 lb/hr.

2.1.2.7 Shale Disposal

The same control applies here as was previously discussed in Section 2.1.1.7, the only difference being that the shale disposal rate increases from 9400 tons/day to 41,000 tons/day. Eighty acres is still the maximum anticipated unrevegetated acreage at any one time.

2.2 Start-Up and Upset Conditions

From the standpoint of air pollution control, the significant aspects of start-ups and upsets are 1) the possibility that the offgas flow rate will be too low for good pollutant dispersion under these conditions, and 2) the possibility that either the Stretford plant or a boiler or thermal oxidizer will malfunction.

The offgas flow rate is itself not the critical flow; rather, the critical flow is the stack flow rate. If fewer retorts are in use than called for in the final design, the stack flow rate can be sustained by continuing to supply the necessary volume of air to the stack directly from the blowers. This will keep the exit velocity up and thereby help disperse the exhaust pollutants. Such a practice will lower the exhaust temperature somewhat, but counterbalancing this effect is the fact that there will also be a smaller amount of pollutants to disperse. This approach will not violate the regulation against dilution to meet emission limitations. Since emission levels will already be far below the emission limits; dilution is not being used to meet the limits.

The Stretford plant that removes hydrogen sulfide from the offgas will be modularized. Part of the plant can be out of commission without causing the complete plant shutdown. A measure of excess capacity can also be provided to take care of cases where just one or two modules are out-of-service. Also, a fraction of the operating retorts can be temporarily shut down if necessary in order to match the input to the Stretford plant with its active capacity.

The boilers or thermal oxidizers will also be modularized so that a segment can be non-operating without jeopardizing whole-plant operation. As before, if the active capacity of these units is less than required by the retort offgas, then some of the retorts can be shut down until the active capacity is adequate.

The duration of start-up or upset conditions depends on the degree of modularity. This is one of the design-optimization aspects to be addressed later this year.

Thermal oxidizers will be utilized during upset as opposed to direct flaring; this has the advantage of the added diffusion afforded by use of relatively tall stacks.

2.3 Potentially Hazardous Emissions

Potentially hazardous emissions that are envisioned are hydrogen sulfide, arsenic, arsine, and mercury. Polynuclear aromatics (PNA) and other carcinogens may possibly be potential problems for which additional information will be gathered early in the ancillary phase.

Estimates have been made for arsenic, arsine, and mercury for full-scale operations and are presented here. If compliance is achievable for full scale, it is more readily achieved for the ancillary phase.

2.3.1 <u>Hydrogen Sulfide</u>

Hydrogen sulfide will be stripped from the offgas in the Stretford plant; any residue will be converted to sulfur dioxide when the offgas is burned. Thus, hydrogen sulfide will not be emitted to the atmosphere.

2.3.2 <u>Arsenic and Arsine</u>

The exact levels of arsenic or arsine that may occur in the exhaust are not known, but it is known that arsenic accumulates preferentially in asphalts and other heavy ends of the product oil. Light fractions, i.e. those with boiling points less than 375°F, contain less than 2 ppm arsenic by weight. It is assumed that the arsenic content in the organic fraction of the offgas also does not exceed 2 ppm by weight. Two ppm by weight in the organic fraction of the offgas is equivalent to 0.52 ppm by weight in the exhaust.

Allowable concentrations of arsenic and arsine at ground level are calculated on the basis of Colorado Air Quality Control Regulation No. 8. This regulation limits ground level concentrations of a pollutant to 1/30 of its Threshold Limit Value (TLV), i.e. 0.5 mg/m^3 for arsenic and 0.2 mg/m^3 for arsine. The ground level concentration limits for arsenic and arsine are thus 17 ug/m^3 and 7 ug/m^3, respectively.

The allowable ground level concentrations are then converted to allowable emission rates by using the dilution factor for the stack exhaust. The dilution factor is determined by knowing that the stack must be such that sulfur dioxide is diluted from 8 ppmv to 15 ug/m^3 (24-hour average), which is the most demanding dilution requirement. (Note: All effects are converted to moles and then converted back to concentrations by weight or volume as required.) The allowable emission rates are 19.5 ppm by weight for arsenic and 7.9 ppm by weight for arsine.

Thus if the allowable emission rates and the maximum expected emission rates are compared to determine if there is a potential problem, thirty-five times more arsenic and fifteen times more arsine could be emitted than is expected without violating Regulation No. 8.

2.3.3 Mercury

Mercury emissions have been estimated* for full-scale operations utilizing Donnell and Shaw (1977)**. They show that 2% of the initial mercury remains in the spent shale. Between 15 and 16% goes into the retort water (water from the retorting action). Twenty-five percent goes into the oil and 58% goes off in the gaseous products.

It is assumed that the dilution factor between the stack and the ground is that corresponding to dilution of 174 lb/hr of SO_2 at the stack to 15 ug/m^3 on the ground at the point of maximum impact (the Colorado Ambient incremental 24-hour standard). The 175 lb/hr from offgas burning corresponds to scrubbing the offgas to an equivalent H_2S concentration of 15 ppmv before burning. Donnell and Shaw measured 0.43 ppm Hg in the shale by weight; thus .58 x 0.43 yields 0.25 ppmv Hg by weight in the offgas corresponding to a daily production rate of 48 lb/day. In full-scale, the boiler is powered by the offgas exhaust so that the concentration of mercury in the boiler exhaust is 0.027 ppmv. The dilution at ground level is 0.00083 ug mole/m^3. The State of Colorado Regulation No. 8 allows 1/30 of a specified threshold limit value; this corresponds to 0.00166 ug mole/m^3 for alkyl mercury compounds. Thus our predicted emissions are one-half those allowable if all the mercury is in the form of alkyl compounds; the predicted emissions are approximately one-tenth those allowed if none of the mercury is in the form of alkyl compounds.

2.4 Design Alternatives

2.4.1 Alternatives to the Stretford Process

As previously stated, if the organic sulfur compounds prove to be sufficiently low in concentration, then the treatment will be with the Stretford or similar process to remove hydrogen sulfide. If organic sulfur compounds are too abundant (in terms of the sulfur dioxide they would form), they will be removed by other appropriate means such as alkaline scrubbing. Monoethanolamine (MEA) may be used to remove carbonyl sulfide and will remove hydrogen sulfide. The gas may then be further treated with a catalyst (e.g. UOP Merox) and caustic; this will remove mercaptans. This sequence will eliminate the need for Stretford processing. Carbon dioxide may be recovered, if desired, from the MEA. In any event, the equipment selected would employ the best available commercial control technology to hold emissions below regulatory limits.

2.4.2 Decrease the Stretford Stripping Level

The nominal design strips the offgas down to 15 ppmv H_2S equivalent. It was shown in the modeling study in Appendix A that stripping the offgas down to 83 ppmv H_2S equivalent complied with all Federal and State air quality regulations. This will be further investigated as a design alternative.

* Ruskin, A.M. - Memo to R.E. Thomason - 19 May 1977 - Mercury Emissions to the Atmosphere

** Donnell, J.R. and Shaw, V.E.: Mercury in Oil Shale from the Mahogany Zone of the Green River Formation, Eastern Utah and Western Colorado, J. Res. U.S.G.S., 5, No. 2 - Mar-Apr 1977, pp 221-6.

2.4.3 Alternatives to the M[illegible] Vent Baghouse

Because of the large volume of mine ventilation air, the size of the baghouse is expected to be very large. Also, if the mine air were to be cleaned, it would be beneficial to [illegible] miners to clean it to a higher degree underground. Wet suppression techniques coupled with baffling, portable cyclones, and portable baghouses will be investigated as to feasibility for use underground.

2.4.4 Shale Disposal Underground

The MDDP cites disposal of raw shale in the mine as a viable alternative for further study.

2.5 Applicable Air Quality Standards

Table 2.5-1 presents three applicable groups of standards: 1) National Ambient Air Quality Standards (NAAQS), (Column 6), 2) Federal Prevention of Significant Deterioration (PSD) Regulations, (Column 7), and 3) State of Colorado Ambient Air Quality Standards, (Columns 8 and 9). Note that all NAAQS and the Colorado Ambient Standards for particulates are absolute values so that "background" values obtained from an environmental baseline must be added to oil-shale plant increments for comparison with these standards. PSD for SO_2 and particulates and Colorado standards for SO_2 are incremental values.

The background values obtained from C-b's two-year environmental baseline are presented in column 3 of Table 2.5-1. The reader is referred to the discussion on page 30 in the text of Appendix A relative to the high NMHC background levels. The Federal Register of December 21, 1976 recommends using annual particulates background for 24-hour PSD increments where the source is fugitive dust as has been demonstrated for C-b's particulates background.

Table 2.5-2 presents applicable emission limits (from stacks) from Regulation No. 1 of the Colorado Air Pollution Control Commission. They are given in lbs/10^6 BTU for particulates and ppmv for sulfur dioxide.

2.6 Demonstration of Compliance

The EPA Valley model, as described in Appendix B, has been utilized to estimate maximum ground level concentrations due to the shale oil operations and associated fugitive sources. These modeling results for the ancillary phase are presented in Appendix A and summarized in column (4) of Table 2.5-1 at the "peak" receptor for all averaging times corresponding to air quality standards.

It is pertinent to review some of the major modeling conclusions:

1. All Federal and State Prevention-of-Significant-Deterioration standards are met everywhere for the ancillary phase.

2. Fugitive-dust concentrations have been estimated for the major access road and for the raw shale pile. It is concluded that:

   a. The major access road must be paved.

   b. The shale pile concentrations can be held within standards provided no more than 80 acres (unrevegetated) are exposed in any one year and 80% control is achieved by application of chemical stabilizers.

3. The nominal design for the offgas treatment facility utilizes a

COMPARISONS OF MAXIMUM GROUND-LEVEL CONCENTRATIONS IN THE ANCILLARY PHASE WITH STANDARDS (ug/m^3)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Standard			
						Federal(B) PSD (Class II)	Colorado Ambient (Cat. I	
Pollutant	Averaging Time	Appropriate Background Level	Modeling Increment	Sum (3)and(4)	NAAQS(A)		Absolute(C)	Incrementa
SO_2	Annual	1.3	0.2	1.5	80	15		3
	24-hour	112	3.7	115.7	365	100		15
	3-hour	87.7	14.8	102.5	1300	700		75
Particulates	Annual	10.7(1)	9.3	20.0	60	10	45	
	24-hour	11.2(2)	12.6	23.8	150	30	150	
NO_2	Annual	21.0	6.6	27.6	100			
NMHC	3-hour (6-9 A.M.)	2597(3)	26	2623(3)	160			
CO	8-hour	4502	447	4949	10000			
	1-hour	4651	8714	13365	40000			
Oxidant	1-hour	160	0	160	160			

(1) Geometric Mean of 24-hour

(2) Arithmetic Mean of 24-hour as suggested in text

(3) See reference to page 30 of Appendix A in the text

(A) Compare Columns (5) and (6)
(B) " " (4) and (7)
(C) " " (5) and (8)
(D) " " (4) and (9)

TABLE [illegible]-2

COMPARISON OF ANCILLARY AND FULL SCALE EMISSIONS WITH EMISSION LIMITS[1]

	Emission Rate	Emission Limit	
Particulates, lb/hr			
Ancillary Phase			
Burned Offgas	<7.4	108	0.1 lbs/10^6 BTU
Oil Fired Boiler	16.3	20.3	0.14 lbs/10^6 BTU
Full-Scale Operations			
Burned Offgas	<74	986	0.1 lbs/10^6 BTU
Sulfur Dioxide, ppmv			
Ancillary Phase			
Burned Offgas	7.2	150	
Oil-Fired Boiler	11.8	150	
Full-Scale Operations			
Burned Offgas	7.8	150	

(1) Colorado Air Pollution Control Commission Regulation No. 1

Stretford type unit whose output is normally at 15 ppmv equivalent H_2S. For the stack configurations summarized on Table 2.1-1 with concentrations from the major sources (mine vent, steam generating facility, shale pile) fixed, emissions from the offgas treatment facility up to 83 ppmv equivalent H_2S will meet all Federal and State PSD regulations.

2.6.1 Compliance with Natural Ambient Air Quality Standards

Compliance with the NAAQS is demonstrated by comparing columns (5) and (6) of Table 2.5-1. Reference is again made to Page 30 of Appendix A for a discussion of the high NMHC background levels.

2.6.2 With Federal PSD Regulations

By comparing column (4) of Table 2.5-1 with column (7) compliance is demonstrated with Federal PSD regulations for ground level concentrations at the "peak" receptor.

2.6.3 With Colorado Ambient Standards

By comparing column (5) with (8) compliance with Colorado absolute standards for particulates is demonstrated. By comparing columns (4) and (9) compliance with Colorado incremental standards for SO_2 is demonstrated.

2.6.4 With Colorado Emission Regulations

By comparing the emission rate from the ancillary facility in Table 2.5-2 with the emission limit from Colorado's Regulation No. 1 compliance is demonstrated. The regulation for particulate rates is stated in lbs/10^6 BTU units which is converted to lbs/hour on the table. Rates for SO_2 are specified in ppmv.

Note: Compliance with hazardous emission regulations has been addressed in Section 2.3.

3. CONTROL PLAN FOR COMMERCIAL OPERATIONS

It is to be noted that permits-to-construct from the State of Colorado are expected to be obtained by operational phases, i.e., a permit will be obtained initially for ancillary development, followed by full-scale operations at a later date. Engineering design details are available sooner for the ancillary phase than for full-scale; therefore, improved emissions estimates for full-scale will be available only in the future. Rough-terrain air diffusion models are undergoing rapid state-of-the-art improvements to more closely depict "real-life". Finally, "learning" from the ancillary phase will be applied to all permitting and modeling of full-scale in this phased approach. It is for all these reasons that the degree of detail for the full-scale control plan is less than that presented for the ancillary phase.

3.1 Emissions Summary

Full-scale emissions are accompanied by explanatory and source footnotes summarized on Table 3.1-1 for the following major emission sources: 1) In-situ process (i.e., the off-gas treatment facilities), 2) the mine vent, 3) the shale disposal area, and 4) the fuel tank storage. The last column in the right lists the total emissions by pollutant as contained in Appendix B for the full-scale surface - retorting TOSCO II process which produced 50,000 bbl/day of oil for a mined-out shale tonnage of 66,000 tons/day over a 20 year mine life. The present in-situ process produces 57,000 bbl/day of oil for a mined-out shale tonnage of 41,000 tons/day over a 60 year mine life.

The mine vent emissions are identical to those of the ancillary phase since the mining for that phase is full-scale. The in-situ gas treatment facility is a scaled up modular version of the Stretford type (but see design alternative notes in Sections 2.4.1 and 2.4.2) utilized in the ancillary phase. In the commercial phase, boilers burn the off-gas from the Stretford plant instead of using fuel oil. There is one less stack for this combination as a result. The shale disposal pile operates under the same 80-acre acreage constraint as previously. Locations of the gas treatment and steam generating facilities change from those shown in Figure III-A for the ancillary phase to the location shown on Figure I-A on the MDDP.

3.2 Demonstration Of Compliance

The method of approach is based on the following premises:
1) Modeling was investigated for the full-scale TOSCO II surface-retorting process (Appendis B). Compliance was demonstrated off-tract with all Federal and State Prevention-of-Significant-Deterioration regulations. The critical case corresponds to the 24-hour State standard for SO_2 of 15 ug/m^3 under Stable (F) conditions.

2) For the principal SO_2 emitters, the in-situ process stacks are hotter and of higher volume flow than those for the TOSCO II process.

3) The total SO_2 emissions are lower for the in-situ process (181 vs 251 lbs/hr).

TABLE 3.1-1

FULL-SCALE EMISSIONS, lb/hr

Pollutant	Averaging Time	In-Situ Process[1]	Mine Vent[2,3,4]	Shale Disposal	Tank Storage	Total	Original DDP[5]
Particulates	24 hour	<74	16[6]	29[7]	-	<119	361
	Annual	<74	15[6]	29[7]	-	<118	
SO_2	3 hr	174[8]	45[9]	-	-	219	
	24 hr	174[8]	7[9]	-	-	181	251
	Annual	174[8]	2[9]	-	-	176	
CO	1 hr	84	19,140[10]	-	-	19,224[11]	
	8 hr	84	2,450[10]	-	-	2,534[11]	
	Annual	84	257[10]	-	-	341[11]	51
THC	3 hr	15	59[12]	-	103[13]	177	353
	Annual	15	12	-	103[13]	130	
NO_x	Annual	588	300[14]	-	-	888	1,996

1 In situ emissions are estimated from the combustion of off-gas. Estimates are made from EPA AP-42 in proportion to higher heating values for gaseous fuels (used by EPA on page 1.5-2). No fuel burning above the combustion of off-gas is needed for power or heat.

2 Emission rates from the mine vent depend heavily on the amount of time over which the reaction products from a rubbling blast are averaged. Mine vent emissions are identical to those of the ancillary phase whose detailed breakdown is presented on Table 2.1-2.

TABLE 3.1-3 (Cont'd)

[3] Rubbling is assumed to occur not more than once per 24-hour period and not more than 70 times per year.

[4] It is assumed that 7,000 gallons of diesel fuel are burned underground daily. Diesel emissions are estimated from EPA AP-42, p. 3.1.5-2 and assume $\leq$ 0.023% sulfur by weight.

[5] Figures for the original DDP plant design are from the report to the Area Oil Shale Supervisor dated 1 November 1976, enclosed here as Appendix B.

[6] Crushing is estimated to produce 0.5 lb. of particulates/ton of shale blasted; see EPA AP-42, Table 8.20-1. Blasting is estimated to produce no more particulates than crushing. Handling and hauling are estimated to produce no more particulates than four times the amount produced on crushing. Eighty per cent of the particulates produced are assumed to settle out in the mine (EPA AP-42). Collection efficiency of the balance is estimated at 99%. Five per cent of the particulates formed in rubbling are assumed to escape from the retort into the mine.

[7] The maximum acreage of raw shale exposed at any one time is estimated to be 80 acres. If emissions were uncontrolled it is estimated that they would be 8 tons/acre/yr. Control of fugitive dust emissions from shale disposal operations is estimated to be 80%.

[8] The Stretford plant is assumed to emit 15 ppmv H_2S maximum.

[9] ANFO is assumed to be the explosive used in mining and rubbling. Fuel oil with 0.023% sulfur is assumed.

[10] Blasting is assumed to produce 0.04 lb. of CO per lb of ANFO, due to non-ideal reaction behavior. Rubbling produces 18,800 lb of CO once every 5 days.

[11] For pollutant dilution adequate for SO_2 dispersal, the estimated ground level concentrations of CO are 3022 ug/m^3 for 1-hour averaging times and 268 ug/m^3 for 8-hour averaging times. These numbers are significantly less than the corresponding standards of 40,000 ug/m^3 and 10,000 ug/m^3.

[12] It is assumed that 0.5% of the fuel oil in ANFO is not burned in blasting and comes out the mine vent as hydrocarbons.

[13] The figures for losses from "tank storage" also include losses from handling product oil, whether stored or not. Storage of five days' production is assumed. Storage losses are estimated to be 0.0052 lb/day/1000 gallons and working losses are estimated at 1.0 lb/1000 gallons throughout (EPA AP-42, pp. 4.3-8.9).

[14] Blasting is assumed to produce 0.04 lb of NO_2 per lb of ANFO, due to non-ideal reaction behavior.

4) The implication of item 2) is that the exhaust plumes from the stacks for the in-situ process will rise higher causing additional pollutant dispersion and lower ground level concentrations for the in-situ process. (Note that "effective" stack height is the sum of actual height plus plume rise derived from its buoyancy or momentum or both). Effective stack heights are shown on Table 3.2-1 and are higher for the in-situ case.

5) One additional consideration is that the mine vent for the TOSCO II was not reported to contain SO_2, but is considered for the in-situ process as a relatively small emitter ($\leq$4% of the total SO_2). Its plume rise for a stable case is 48 meters at a wind speed of 2 m/sec; with an 88 m stack height its effective stack height is 136 m. Because of the relatively low percentage contribution of the mine vent to SO_2 emissions this is deemed to be only of minor consequence.

6) Since by item 3) the emissions are lower for in-situ and by item 4) the plume rises higher, the ground level maximum concentration of SO_2 for the in-situ process is lower than that for the TOSCO II process and will therefore comply with Federal and State PSD regulations.

Comparisons of SO_2 and particulates with the State of Colorado emission regulations for full-scale operations are made on Table 2.5-2 demonstrating compliance.

TABLE 3.2-1

COMPARISON OF EFFECTIVE STACK HEIGHTS FOR THE MAJOR SO_2 EMITTERS IN THE TOSCO II SURFACE - RETORTING AND THE IN-SITU PROCESS

PROCESS	EMITTER	STACK HEIGHT (m)	PLUME RISE (m)*	EFFECTIVE STACK HEIGHT (m)
TOSCO II	Preheater	125	107	232
	Elutriator	↓	91	21[illegible]
	Sulfur Plant	↓	50	1[illegible]
IN-SITU	Gas Treatment	25	217	242

* F Stability, 2 m/sec wind

APPENDIX A

AIR QUALITY CONTROL PLAN FOR

TRACT C-b

Dated June 10, 1977

(This supplementary information contains modeling results for in in-situ ancillary phase)

APPENDIX A IS FOUND ON THE

FOLLOWING PAGES

APPENDIX B

AIR QUALITY CONTROL FOR

OIL SHALE TRACT C-b

Dated November 1, 1976

(Supplementary Information)

NOTE: This contains the modeling results for the full-scale surface-retorting TOSCO II process.

APPENDIX B IS FOUND IN THE SEPARATELY BOUND REPORT ENTITLED," Air Quality Control for Oil Shale Tract C-b"

AIR QUALITY CONTROL PLAN FOR TRACT C-b

JUNE 10, 1977

AUTHORS:

SPENCER A. BULLARD
QUALITY DEVELOPMENT ASSOCIATES, INC.

ARNOLD M. RUSKIN, PH.D.
CLAREMONT ENGINEERING COMPANY

GEORGE E. FOSDICK, PH.D.
C-b SHALE OIL PROJECT

PREFACE

The C-b Venture has modeled air pollutant dispersion of its ancillary phase in support of its Detailed Development Plan Modification. The reader is referred to the DDP Modification and "Air Quality Control for Oil Shale Tract C-b," which was submitted in support of the original DDP, for background information pertaining to the work described here.

TABLE OF CONTENTS

INTRODUCTION AND CONCLUSIONS

Atmospheric pollutant emissions have been estimated and their dispersions modeled for the ancillary phase of the development of Tract C-b. The purpose has been to demonstrate the feasibility of meeting air quality regulations during this phase of development. All air quality regulations can be met with reasonable stacks providing appropriate limits are observed in designing the plant.

Critical aspects that need closest attention are the sulfur content of the offgas and the extent of the raw shale disposal area. A twenty-five meter stack will allow up to 83 ppmv equivalent H_2S in retort offgas before it is burned, and a taller stack might allow more. The shale pile must be restricted to a maximum of 80 contiguous acres of unvegetated shale, unless dusting can be reduced below 1.6 tons/acre/year.

The material below describes the ancillary phase in relation to full-scale development, the expected emissions, the meteorology of the site, the modeling procedures used, and the resulting maximum ground level concentrations expected. Also attached is an evaluation of the impact of trace emissions of hazardous elements. Detailed calculations are available from the operator upon request.

THE ANCILLARY PHASE OF C-B DEVELOPMENT

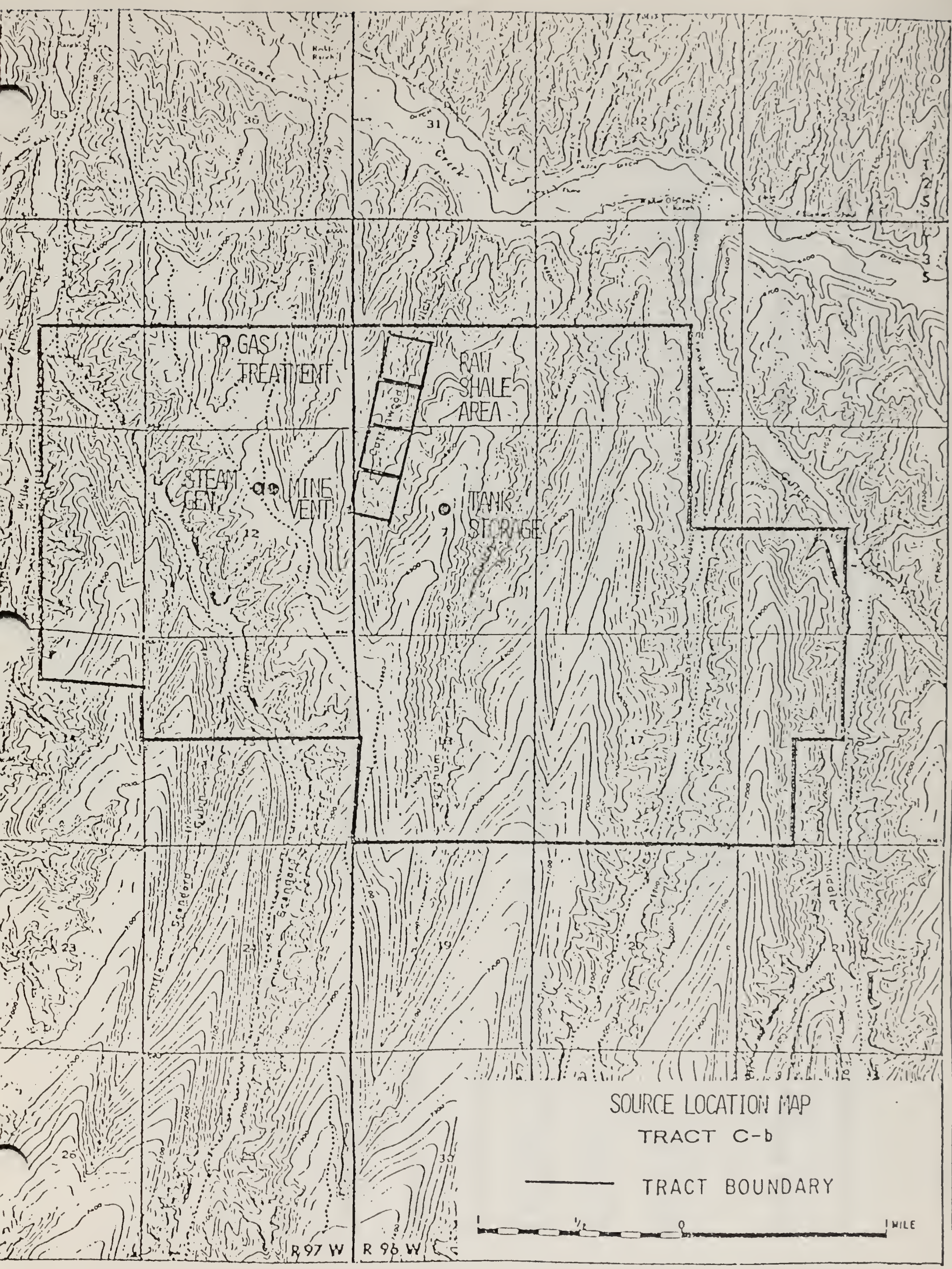
THE ANCILLARY PHASE OF C-B DEVELOPMENT REFERS TO THE OPERATION OF TWO TO FOUR FULL-SIZE RETORTS. THIS CORRESPONDS TO ABOUT 10 PERCENT OF FULL-SCALE RETORTING, DEPENDING UPON THE EXACT NUMBER AND SIZE OF RETORTS USED. THE PURPOSE OF THIS PHASE IS TO GAIN EXPERIENCE IN PREPARING AND OPERATING RETORTS ON THE C-B TRACT BEFORE UNDERTAKING FINAL DESIGN AND CONSTRUCTION OF THE FULL-SCALE FACILITY. THE PHASE IS THUS A PILOT FOR COMMERCIAL DEVELOPMENT OF THE SITE AND WILL PROVIDE AN OPPORTUNITY TO CONFIRM OR MODIFY OPERATING PROCEDURES AND MONITORING TECHNIQUES AND TO TRAIN PERSONNEL FOR FULL-SCALE OPERATIONS.

WHILE THE ANCILLARY RETORTS ARE BEING OPERATED, MINING OF THE MAIN FACILITY WILL BE PROCEEDING UNDERGROUND AT FULL-SCALE RATES. ALSO, RAW SHALE WILL BE REMOVED AND PLACED IN A SHALE DUMP OR DUMPS ON THE SURFACE AT FULL-SCALE RATES. THUS, THE ANCILLARY PHASE INCLUDES FULL-SCALE MINING AND RAW SHALE DISPOSAL AND 10 PERCENT OF FULL-SCALE RETORTING.

THE OPERATION OF RETORTS DURING THE ANCILLARY PHASE DIFFERS FROM COMMERCIAL OPERATIONS IN ONE SIGNIFICANT RESPECT: A STEAM BOILER WILL BE FIRED WITH FUEL OIL INSTEAD OF BURNING OFFGAS TO HEAT THE BOILER. THIS RESULTS IN AN ADDITIONAL EMISSION SOURCE WHICH WILL NOT EXIST IN FULL-SCALE OPERATIONS.

THERE WILL BE THREE EXHAUST STACKS FOR THE ANCILLARY PHASE: (1) THE MINE VENT EXHAUST STACK, (2) THE BOILER EXHAUST STACK, AND, (3) THE OFFGAS COMBUSTION EXHAUST STACK. THE FIRST TWO ARE LOCATED TOWARD THE CENTER OF THE TRACT, ON RELATIVELY HIGH GROUND, AS SHOWN IN THE ATTACHED MAP. EACH OF THESE TWO IS ASSOCIATED WITH A HOIST HOUSE AND MUST BE AS TALL OR TALLER THAN THE CORRESPONDING HOIST HOUSE. THE THIRD STACK, FOR THE OFFGAS COMBUSTION EXHAUST, IS NEAR THE NORTHERN EDGE OF THE PROPERTY, AS SHOWN ON THE MAP.

OPERATING CONDITIONS AND ASSUMPTIONS ARE SHOWN IN THE FOLLOWING PAGES. EMISSION ESTIMATES APPEAR ON PAGE 7.


GAS TREATMENT
RAW SHALE AREA
STEAM GEN
MINE VENT
TANK STORAGE
R 97 W
R 96 W
SOURCE LOCATION MAP
TRACT C-b
TRACT BOUNDARY
1/2
0
1 MILE

OPERATING CONDITIONS FOR FEASIBILITY MODELING OF THE ANCILLARY PHASE

PRODUCTION RATE:	5,700 BARRELS OF OIL PER DAY. (10% OF FULL-SCALE PRODUCTION.)
MINING RATE:	41,134 TONS OF SHALE PER DAY. (FULL-SCALE MINING.)
RETORT SIZE:	200′ x 200′ x 310′.
EXHAUST LOCATIONS:	SEE ACCOMPANYING MAP.
EXHAUST EMISSIONS:	SEE ACCOMPANYING TABLE.
MINIMUM MINE VENT HEIGHT:	290′, DETERMINED BY HOISTHOUSE REQUIREMENTS.
MINIMUM BOILER STACK HEIGHT:	170′, DETERMINED BY HOISTHOUSE REQUIREMENTS.
BOILER FUEL:	620 BARRELS PER DAY OF FUEL OIL, 0.023% SULFUR MAXIMUM.
EXPLOSIVE:	ANFO WITH 6% FUEL OIL. THE SULFUR CONTENT OF THE FUEL OIL IS ASSUMED NOT TO EXCEED 0.023%. IT IS ASSUMED THAT 0.5% OF THE FUEL OIL IS NOT BURNED AND IS VENTED IN THE MINE EXHAUST.
POWDER FACTORS:	0.7 LB PER TON FOR RUBBLING AND 0.5 LB PER TON FOR ORDINARY MINING.
BLASTING FREQUENCY:	ORDINARY BLASTING ONCE EACH EIGHT-HOUR SHIFT AND RUBBLING ONCE EVERY FIVE DAYS; I.E. NOT MORE THAN ONCE PER DAY AND NOT MORE THAN 70 TIMES PER YEAR.

Blasting Frequency:	Ordinary blasting once each eight-hour shift and rubbling once every five days, i.e. not more than once per day and not more than 70 times per year.
Blasting Byproducts:	Assumed not to exceed 0.5 lb of dust per ton. Ninety-five percent of the dust from rubbling is assumed to remain in the retort.
	Assumed not to exceed 0.04 lb of CO per lb of ANFO and 0.04 lb of NO_x per lb of ANFO.
Primary Crushing & Breaking:	Done in the mine and assumed to produce not more than 0.5 lb of dust per ton.
Rock Handling & Hauling:	Assumed to produce not more than 2 lb of dust per ton.
Dust Control:	Eighty percent of the particulates produced in the mine are assumed to settle out in the mine. Collection efficiency of the balance is assumed to be 99 percent.
	Control of dust from the shale pile is assumed to be 80 percent. It is assumed that the emissions of fugitive dust would be 8 tons per acre per year if they were not controlled.
Diesel Mining Equipment:	Uses 0.023 percent sulfur max. fuel, if used at all. Maximum use is 7,000 gallons per day.
In Situ Offgas:	Stripped of sulfur compounds down to an equivalent of 15 ppmv H_2S then burned in a thermal oxidizer and exhausted through a 25 meter stack. Non-sulfur emissions are estimated from the higher heating value (EPA AP-42, page 1,5-2, second edition, March 1975).
Hydrocarbon Losses:	Standing storage losses are assumed to be equivalent to that of a distillate fuel, i.e., 0.0052 lb per day per 1,000 gallons. Storage is assumed to be one tank measuring 120' diameter x 56' high with a floating roof. Working losses are also assumed to be equivalent to that of a distillate fuel, i.e., one lb per 1,000 gallons throughput. "Tank Storage" in the table of emissions includes both kinds of losses. (Source: EPA AP-42, pp 4.3-8,9)

EXHAUST EMISSIONS FOR THE ANCILLARY PHASE

EXHAUST EMISSIONS FOR THE ANCILLARY PHASE ARE SHOWN IN THE FOLLOWING TABLE. THESE ESTIMATES ARE USED AS SOURCE EMISSIONS IN THE AIR POLLUTION MODELING THAT IS DESCRIBED SUBSEQUENTLY. THE TABLE IS BASICALLY SELF-EXPLANATORY, BUT THREE ITEMS REQUIRE EXPLANATION.

FIRST, EMISSION RATES FOR THE MINE VENT DEPEND CRITICALLY ON THE TIME OVER WHICH RUBBLING BLASTS AND ORDINARY MINE BLASTING ARE AVERAGED. SUCH BLASTS ARE OF VERY SHORT DURATION AND SPACED AT MODERATE TO LONG INTERVALS. THUS, THE EMISSION RATES ON A PER HOUR BASIS DEPEND IN PART UPON THE AVERAGING TIMES.

SECOND, SULFUR DIOXIDE EMISSIONS SHOWN FOR THE IN-SITU OFFGAS CORRESPOND TO AN EQUIVALENT OF 15 PPMV H_2S WITH A 25 METER STACK. IT IS SHOWN ON PAGE 34 THAT UP TO 83 PPMV H_2S EQUIVALENT IS PERMISSIBLE WITHOUT VIOLATING AIR QUALITY REGULATIONS. LEVELS REACHED DEPEND UPON OFFGAS COMPOSITION AND GAS TREATMENT PROCEDURES, BOTH OF WHICH ARE YET TO BE SPECIFICALLY DEFINED. THE 83 PPMV LEVEL (MAXIMUM) IS TO BE CONSIDERED AS A DESIGN ALTERNATIVE IN THE DETAILED DEVELOPMENT PLAN.

THIRD, THE PARTICULATE EMISSIONS SHOWN FOR SHALE DISPOSAL CORRESPOND TO 80 ACRES OF UNVEGETATED SHALE PRODUCING 1.6 TONS/ACRE/YEAR AFTER DUST CONTROL. THE DUST PRODUCTION RATE IS SUBJECT TO CHANGE AS BETTER DATA ARE OBTAINED. IF LOWER PRODUCTION RATES ARE MEASURED, THEN A GREATER NUMBER OF ACRES CAN BE UNVEGETATED AT ANY ONE TIME, WHICH MAY FACILITATE ECONOMICAL DEVELOPMENT OF THE SHALE DISPOSAL AREA.

EXHAUST EMISSIONS FOR THE ANCILLARY PHASE, LB/HR[1]

POLLUTANT	AVERAGING TIME	IN-SITU GAS AFTER TREATMENT AND BURNING	MINE VENT[2]	BOILER EXHAUST	SHALE DISPOSAL	TANK STORAGE
PARTICULATES	24-HR	<7.4	16	16.3	22[2]	-
	ANNUAL	<7.4	15	16.3	22[2]	-
SO_2	3-HR	17.4[2]	45	3.6	-	-
	24-HR	17.4[2]	7	3.6	-	-
	ANNUAL	17.4[2]	2	3.6	-	-
CO	1-HR	8.4	19,140	4.3	-	-
	8-HR	8.4	2,450	4.3	-	-
	ANNUAL	8.4	257	4.3	-	-
THC	3-HR	1.5	59	3.3	-	11
	ANNUAL	1.5	12	3.3	-	11
NO_x	ANNUAL	59	300	87	-	-
FLOW RATE		240,000 SCFM	624,000 SCFM	30,070 SCFM		
TEMPERATURE		>400°F	>3°F ABOVE AMBIENT AND ≥35°F	400°F		

1 PLEASE REFER TO THE TABLE OF OPERATING CONDITIONS FOR DESIGN PARAMETERS AND CONSTRAINTS.

2 PLEASE REFER TO PAGE 6 OF THE TEXT FOR A DISCUSSION OF THESE NUMBERS.

VEHICLE POLLUTION ON PICEANCE CREEK ROAD

Vehicular emissions were analyzed in the access corridors leading to Tract C-b, specifically for two segments of Piceance Creek Road from the Tract C-a turnoff to the P-L Ranch and from the start of Piceance Creek valley (on the east) to the P-L Ranch. A simple box-model was used to predict concentrations of NO_x, CO, and THC in two portions of the Piceance Creek valley for three inversion heights (150, 250, and 400 feet) and two wind speeds (2 and 6 mph). Concentrations reached at the end of one hour for both portions of Piceance Creek Valley are given on Figures II C-6 through II C-11 of <u>Quarterly Data Report #4</u>, for NO_x, CO, and THC. These curves which are based on EPA and State of Colorado emission factors corrected to a 6500 foot altitude were utilized for the 21 mile segment east from theP-L Ranch. During the construction phase the work force is estimated to peak at 2900 workers. For a worst-case, one-man car pools were assumed with a 100% overlap of two shifts occurring in the valley. Total number of cars then became 1934; assuming a ratio of 25 cars to 1 truck, 77 trucks were also added. The emissions for this traffic load utilizing the above-mentioned graphs for an inversion height of 150 feet and an assumed wind speed of 6 mph yield the ground-level concentrations indicated, showing that these worst-case conditions meet the standards.

VEHICLE POLLUTION ON PICEANCE CREEK ROAD

ASSUMPTIONS

21 MILE SEGMENT OF PICEANCE CREEK ROAD
EPA, STATE EMISSION FACTORS @ 6500' FOR 1973 MODEL CARS
2900 WORKERS
3 EQUAL SHIFTS OR 967 WORKERS/SHIFT
1 MAN CAR POOLS
TIME IN PICEANCE CANYON 0.5 HR.
100% OVERLAP OF 2 SHIFTS IN EARLY MORNING
ADD ON 1 TRUCK/25 CARS
BOX MODEL OF PICEANCE CANYON

EMISSIONS (1934 CARS + 77 TRUCKS)

CO 3.82×10^6 GM/HR @ 35 MPH AVG
HC 2.86×10^5 GM/HR

CONCENTRATIONS

CO 3500 $\mu g/m^3$ IN 0.5 HR OR 1750 $\frac{\mu g}{m^3}$ OVER 1 HR

HC 255 $\mu g/m^3$ IN 0.5 HR OR 42.5 $\frac{\mu g}{m^3}$ OVER 3 HRS.

(+ 0 $\mu g/m^3$ THEREAFTER)

CONCLUSIONS

EVEN SINGLE-MAN CAR POOLS CAN MEET CO AND NMHC STANDARDS
MOST PROBABLE CASE IS 2+ MAN CAR POOL

PLUME [illegible]

Briggs plume rise formulae are used in the Valley Model for calculating plume rise when stack diameters, exit temperatures, and exit velocities are input. An option is available to the model user to input a fixed plume rise which is then used throughout all calculations for a particular stack. This option was exercised with the mine vent, raw shale disposal area sources, and the storage tank.

This chart shows the momentum plume rise equation for jets used to determine the plume rise for the mine vent for input ot the Valley Model. The equation is derived from Briggs equation as follows:

$$\Delta H = 3 \left(\frac{V_E}{V_A}\right) D_S \qquad \text{Briggs Equation}$$

$$= \frac{3.82\, V_S}{D_S\, V_A}$$

where: ΔH = plume rise (meters)

V_E = stack exit velocity (meters/sec)

V_A = ambient wind speed (meters/sec)

$V_S = \frac{\pi}{4} V_E D_S^2$ = volume flow rate (meters^3/sec)

D_S = stack diameter (meters)

The mine vent diameter was established as 4.7 meters and not varied throughout the study. This was based on a mine vent standard cubic feet per minute (SCFM) value of 636,534 and a 15 meter/sec exit velocity. The mine vent plume rise was then calculated for each candidate worst-case condition as a function of the ambient conditions on that date and the average wind speed.

PLUME RISE

BUOYANT PLUMES

BRIGGS PLUME RISE FORMULAE ARE USED IN THE VALLEY MODEL.

JETS

FOR CASES $|T_S - T_A| < 50^\circ F$, I.E. MINE VENT, BRIGGS EQUATION FOR JETS IS USED:

$$\Delta H = \frac{3.82\, V_S}{D_S V_A}$$

V_S = ACTUAL STACK VOLUME RATE OF FLOW

D_S = STACK DIAMETER

V_A = AMBIENT WIND SPEED

ΔH = PLUME RISE

METEOROLOGICAL WORST-CASE CANDIDATES

THIS CHART TABULATES THE WORST-CASE METEOROLOGICAL CONDITION CANDIDATES EXAMINED IN THE STUDY. THE TWO-YEAR ENVIRONMENTAL BASELINE WAS SCREENED BY STABILITY CLASS FOR CONSECUTIVE HOURS OF WIND DIRECTION. THIS RESULTED IN IDENTIFICATION OF CANDIDATES, USUALLY MORE THAN ONE, FOR EACH STABILITY CLASS AND DIRECTION. HOURS OF CONSECUTIVE DIRECTION, AVERAGE WIND VELOCITY, DATE OF OCCURRENCE, AMBIENT TEMPERATURE, AMBIENT PRESSURE, AND TIME OF DAY WERE ALL TABULATED. FROM THESE TABULATIONS, ONE CASE FOR EACH DIRECTION AND STABILITY CLASS WAS SELECTED FOR STUDY BASED ON HOURS OF PERSISTENCE AND WIND VELOCITY. THIS TABLE SHOWS THE HOURS, THE AVERAGE VELOCITY, AND THE DATE OF OCCURRENCE OF THE SELECTED CANDIDATES.

THE LONGEST DURATION WAS D STABILITY SSW DIRECTION WITH 25 HOURS AND AVERAGE VELOCITY OF 24.7 MPH. OTHER CASES THAT RESULTED IN HIGH CONCENTRATIONS WAS F STABILITY, SSW 6 HOURS THAT CARRIED POLLUTANTS INTO HIGH ELEVATION BLUFFS NORTH NORTH-EAST OF THE SOURCES, AND A STABILITY WNW 6 HOURS CARRYING POLLUTANTS INTO HIGHER ELEVATIONS TO THE SOUTH EAST.

METEOROLOGICAL WORST-CASE CANDIDATES

Wind Direction	Value	A	B	C	D	E	F
	P	2	4	3	6	2	2
N	V	1.5	6	14	14.5	1.5	3
	D	6-5-74	9-28-76	4-30-76	4-30-76	1-27-75	6-7-75
	P	2	2	2	4	3	2
NNE	V	2.3	8.5	14.5	5	13.3	0.5
	D	12-8-75	9-27-75	9-30-75	4-26-75	9-20-75	9-22-75
	P	2	4	2		2	2
NE	V	2	7.8	10		2	2
	D	12-8-75	7-22-76	6-16-76		1-22-75	8-9-75
	P	2	2				2
ENE	V	3.5	4.5				3
	D	9-8-75	8-20-75				8-29-75
	P	2	4		2	4	3
E	V	2.5	4.5		2.5	4.8	1.7
	D	11-15-75	7-31-76		8-21-75	11-11-75	8-3-75
	P	2	2			3	3
ESE	V	3	9.5			7.3	1.3
	D	12-17-75	5-21-75			8-9-75	2-17-75
	P	4			5	4	6
SE	V	8.5			13.8	7.3	6
	D	5-6-76			7-23-76	8-22-75	2-23-76
	P	3	3	2	3	4	4
SSE	V	1.6	6.0	13.5	15	8.3	3
	D	5-5-75	12-6-75	4-25-76	10-10-75	8-27-75	12-3-75
	P		6	2	11	4	5
S	V		7.8	12.0	22	14.5	4
	D		3-31-76	3-11-76	10-11-75	4-15-75	1-19-75
	P	2	5	4	25	7	6
SSW	V	4	10	14.5	24.2	16	2.5
	D	12-5-75	2-11-76	3-18-75	2-7-75	2-11-75	6-5-75
	P	3	7	3	10	6	3
SW	V	6.5	10.7	14	17.5	14.5	5.3
	D	5-8-76	10-18-75	4-9-75	4-22-75	4-13-75	1-23-75
	P	2	4	2	5	2	2
WSW	V	1.5	9.3	12	18	9.5	5.3
	D	8-1-76	6-11-75	8-23-76	4-9-76	3-23-75	8-2-75
	P	4	4	2	4	10	2
W	V	3.8	7.5	11.5	21.5	4.7	3
	D	2-5-76	4-29-75	6-24-76	1-25-75	9-19-76	8-8-75
	P	6	7	3	6	3	3
WNW	V	3.2	9.6	8	21.1	9	7
	D	10-27-75	5-2-75	1-1-76	3-19-76	2-14-75	9-17-75
	P	3	7	8	4	3	2
NW	V	2	10.9	7.5	16.5	7.3	4.5
	D	10-24-75	12-14-75	10-23-75	11-19-75	2-15-75	1-1-75
	P	3	6	3	4	3	2
NNW	V	2	8.7	14.7	16.8	9.7	3
	D	11-8-75	5-31-75	5-29-75	1-21-75	1-9-75	1-1-75

NOTE: Blank Cases are 1-Hour Duration
P = Persistence in Hours
V = Velocity in Miles/Hour
D = Date of Occurrence in the baseline studies

RANKED LONG-DURATION INVERSIONS GREATER THAN 24-HOURS WITH WIND PERSISTENCE OF ≥6 HOURS

THIS CHART IDENTIFIES LONG-DURATION INVERSIONS THAT OCCURRED DURING THE TWO-YEAR BASELINE PERIOD. IN EACH CASE WIND PERSISTENCE IN ONE STABILITY CLASS AND DIRECTION DURING THE INVERSION PERIOD WAS EQUAL TO OR GREATER THAN 6 CONSECUTIVE HOURS. THE INVERSIONS ARE CHARACTERIZED BY A PREDOMINANCE OF D, E, AND F STABILITY CLASSES AND SOUTH-SOUTHWESTERLY WINDS. ALTITUDES RANGED FROM 200 TO 3000 FEET WITH AVERAGES CLOSE TO 1000 FEET (330 METERS).

THE 24-HOUR INVERSION OCCURRING ON 2/1 THROUGH 2/2/75 WAS SELECTED FOR STUDY USING THE VALLEY MODEL. THIS INVERSION WAS THOUGHT TO BE THE WORST-CASE BECAUSE OF THE LOWEST AVERAGE ALTITUDE, 450 FEET, AND THE PREDOMINANCE OF E STABILITY. AVERAGE WIND SPEED WAS 9 MILES PER HOUR. EIGHT OF THE 24 HOURS WAS FROM THE SSW AND 9 HOURS FROM SSE. MODEL METEOROLOGY INPUTS USED THE ACTUAL PROPORTIONS OF WIND SPEED, WIND DIRECTION, AND STABILITY CLASS IN THE FREQUENCY DISTRIBUTION TABLE.

THIS CASE DID NOT RESULT IN MAX CONCENTRATION VALUES FOR ANY OF THE POLLUTANTS AS GREAT AS OTHER WORST-CASES EXAMINED. THE INCREMENTAL MAX VALUES FOR THE POLLUTANTS FOR THIS LONG-DURATION INVERSION ARE:

AVERAGING TIME	POLLUTANT	MAX VALUE	RECEPTOR	GRID
24 HOUR	SO_2	0.82	NNW 6	200
8 HOUR	CO	65.9	NNW 6	200
1 HOUR	CO	514.3	NNW 6	200
3 HOUR	NMHC	63.6	NNE 1	200
24 HOUR	PART	15.0	NNE 1	200

THESE ARE INCREMENTAL VALUES. THE PARTICULATES VALUE IS BASED ON 160 ACRES OF EXPOSED RAW SHALE IN COTTONWOOD GULCH.

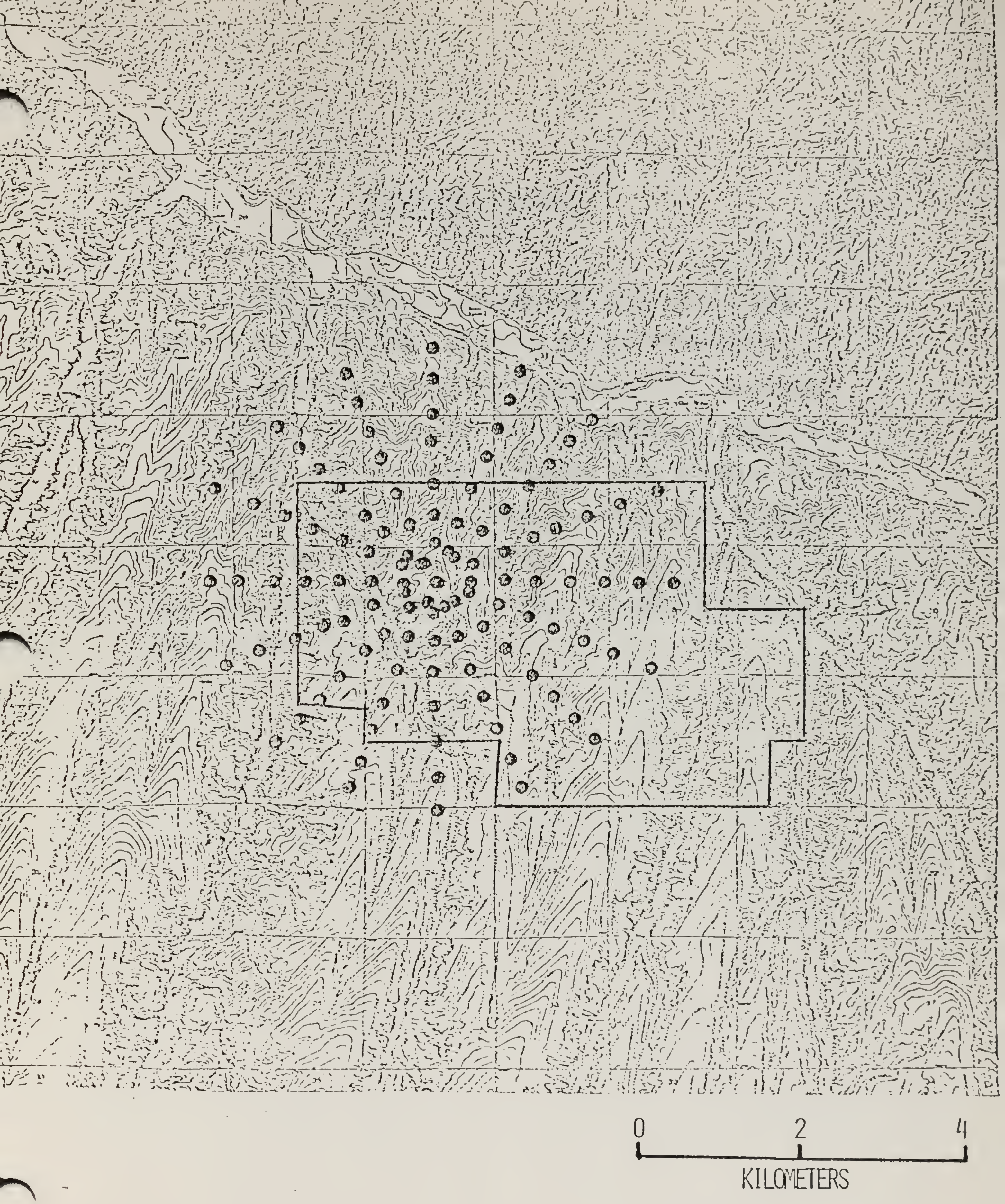
RANKED LONG-DURATION INVERSIONS GREATER THAN 24-HOURS WITH WIND PERSISTENCE OF $\geq$6 HOURS

DATE	DURATION
12/19/74 - 12/21/74	43 Hours
1/14/75 - 1/16/75	37½
2/13/75 - 2/15/75	32½
2/01/75 - 2/02/75	24

RECEPTOR LOCATIONS: 50 GRID

THE EPA VALLEY MODEL WAS USED TO DETERMINE POLLUTANT CONCENTRATIONS AT HYPOTHETICAL GROUND LEVEL RECEPTORS. THE RECEPTOR NETWORK IS AN INPUT TO THE MODEL. THE NETWORK CENTER (ORIGIN) FOR THE COMPUTER RUNS WAS ESTABLISHED AT THE MINE VENT WITH SEVEN RECEPTORS LOCATED ALONG EACH OF THE 16 COMPASS DIRECTIONS. A SCALE FACTOR IDENTIFIED AS GRID IS USED TO PROVIDE SOME CONTROL OVER THE AREA STUDIED. TWO GRID FACTORS, 50 AND 200, WERE USED TO MEASURE GROUND LEVEL CONCENTRATIONS CLOSE IN AND AT MORE DISTANT POINTS RESPECTIVELY.

THIS CHART SHOWS THE LOCATION OF THE 50 GRID RECEPTORS RELATIVE TO THE MINE VENT CENTER AND THE C-B TRACT BOUNDARIES. THE NUMBERING CONVENTION IS N1 THROUGH N7 FOR RECEPTORS IN THE NORTH DIRECTION, NNE 1 THROUGH NNE 7 FOR RECEPTORS IN THE NORTH NORTHEAST DIRECTION, ETC. NOTE THAT RECEPTOR NE 4 IS AT THE TRACT BOUNDARY ALONG COTTONWOOD GULCH. THE HIGHEST CONCENTRATION OF FUGITIVE PARTICULATE MATTER IS EXPECTED AT THIS LOCATION.



RECEPTOR LOCATIONS: 50 GRID

RECEPTOR LOCATIONS:
200 GRID

The 200 Grid receptor locations are shown on this chart relative to the mine vent center and the tract boundaries. This Grid encompasses an area of approximately 11.5 kilometers (7 miles) radial distance from the mine vent and includes high elevations regions both north of Piceance Creek and south of the Tract. Receptor NNE 4 is near Collins overlook with elevation of 7500 feet and is in the predominant down wind direction. Elevations south and south east of the Tract are in excess of 7500 feet above sea level.

RECEPTOR LOCATIONS:
200 GRID

COMPUTER MODEL SOURCE INPUTS

THIS CHART SHOWS THE COMPUTER MODEL SOURCE INPUTS FOR THE CASES RESULTING IN HIGHEST RECEPTOR CONCENTRATIONS FOR EACH OF THE FIVE POLLUTANTS CONSIDERED. ONLY CONDITIONS THAT APPLY TO ASSESSING CAPABILITY OF ANCILLARY FACILITIES AND PHASE TO MEET STANDARDS WAS RUN. STACK HEIGHTS FOR MINE VENT AND STEAM GENERATING FACILITIES WERE DICTATED BY THE FACILITY CONSIDERATION AND NOT THROUGH OPTIMIZATION TO MINIMIZE COST TO COMPLY WITH STANDARDS. ALL UNITS IN THE TABLE ARE METRIC AND ARE DESCRIBED IN APPENDIX A, DESCRIPTION OF VALLEY MODEL, REF. 4.

THE RUN NUMBERS AND TITLES ON EACH OF THE SUB-TABLES IN THE CHART IDENTIFY THE CONDITION AND POLLUTANT RUN. THE FIRST THREE SUB-TABLES ARE FOR ANNUAL AVERAGING TIME FOR SO_2, PARTICULATE MATTER, AND NOX RESPECTIVELY. THE FOLLOWING SUB-TABLES ARE FOR SHORT TERM (24 HOUR OR LESS) AVERAGING TIMES.

COMPUTER MODEL INPUTS

RUN 200ANN7 — OIL SHALE TRACT C-B ANNUAL SO2 CONCENTRATIONS

SOURCE DATA. PLOT 467,936

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	[illegible]	[illegible]	50.	2.1900E+00	*********	0.	6740.	1231.	183.	162.	274.	478.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	2.5000E-01	*********	0.	6020.	99.	53.	44.	274.	276.	4.7	19.5
3 STEAM GENERATOR	458.40	60.00	52.	4.6000E-01	*********	0.	6820.	348.	93.	77.	274.	478.	1.6	15.4

RUN 200ANN8 — OIL SHALE TRACT C-B ANNUAL PARTICULATES CONCENTRATIONS

SOURCE DATA. PLOT 201.955

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	458.43	65.23	25.	9.3000E-01	*********	0.	6740.	1231.	183.	152.	274.	478.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	1.8900E+00	*********	0.	6820.	99.	53.	44.	274.	276.	4.7	19.5
3 STEAM GENERATOR	458.40	60.00	52.	2.0500E+00	*********	0.	6820.	348.	93.	77.	274.	478.	1.6	15.4
4 RAW SHALE AREA 1	462.30	58.40	1.	1.8500E+00	3.	402.	6890.	********	********	********	274.	****	*****	*****
5 RAW SHALE AREA 2	463.20	60.30	1.	1.8500E+00	3.	402.	6850.	********	********	********	274.	****	*****	*****
6 RAW SHALE AREA 3	463.70	62.20	1.	1.8500E+00	3.	402.	6810.	********	********	********	274.	****	*****	*****
7 RAW SHALE AREA 4	464.20	64.10	1.	1.8600E+00	3.	402.	6750.	********	********	********	274.	****	*****	*****

RUN 50ANN9 — OIL SHALE TRACT C-B ANNUAL NOX CONCENTRATIONS

SOURCE DATA. PLOT 660.191

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	453.74	62.13	25.	7.4100E+00	*********	0.	6740.	1231.	163.	152.	274.	478.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	3.7800E+01	*********	0.	6820.	99.	53.	44.	274.	276.	4.7	19.5
3 STEAM GENERATOR	458.33	60.00	52.	1.0900E+01	*********	0.	6620.	348.	93.	77.	274.	478.	1.6	15.4

RUN 200F126 — OIL SHALE TRACT C-B 24-HOUR SO2 CONCENTRATIONS — 0

SOURCE DATA. PLOT 369.459

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	458.43	65.53	25.	2.1900E+00	*********	0.	6740.	1240.	184.	152.	270.	476.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	8.2000E-01	187.	0.	6820.	********	********	********	270.	275.	4.7	14.9
3 STEAM GENERATOR	458.40	60.00	52.	4.5000E-01	*********	0.	6620.	353.	93.	77.	270.	476.	1.6	15.4

RUN 530139 — OIL SHALE TRACT C-B 24-HOUR PART CONCENTRATIONS

SOURCE DATA. PLOT 191.449

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	453.74	62.13	25.	9.3000E-01	*********	0.	6740.	1209.	183.	152.	280.	478.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	2.0200E+00	16.	0.	6820.	********	********	********	280.	282.	4.7	19.9
3 STEAM GENERATOR	458.33	60.00	52.	2.0500E+00	*********	0.	6820.	341.	92.	77.	280.	478.	1.6	15.4
4 RAW SHALE AREA 1	469.90	53.40	1.	9.2400E+00	3.	402.	6890.	********	********	********	280.	****	*****	*****
5 RAW SHALE AREA 2	472.80	61.00	1.	9.2400E+00	3.	402.	6850.	********	********	********	280.	****	*****	*****
6 RAW SHALE AREA 3	474.90	68.70	1.	9.2400E+00	3.	402.	6810.	********	********	********	280.	****	*****	*****
7 RAW SHALE AREA 4	476.70	76.30	1.	9.2400E+00	3.	402.	6750.	********	********	********	280.	****	*****	*****

RUN 53A131 — OIL SHALE TRACT C-B 24-HOUR CO CONCENTRATIONS

SOURCE DATA. PLOT 413.577

SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	453.74	62.13	25.	[illegible]	*********	0.	6740.	1235.	183.	152.	273.	478.	4.0	[illegible]
2 MINE VENT	460.00	60.00	88.	3.0900E+02	55.	0.	6820.	********	********	********	273.	275.	4.7	14.9
3 STEAM GENERATOR	458.40	60.00	52.	1.0000E-01	*********	0.	6620.	350.	93.	77.	273.	478.	1.6	15.4

RUN 50B134 — OIL SHALE TRACT C-B 24-HOUR THC CONCENTRATIONS — 0

SOURCE DATA. PLOT 207.601

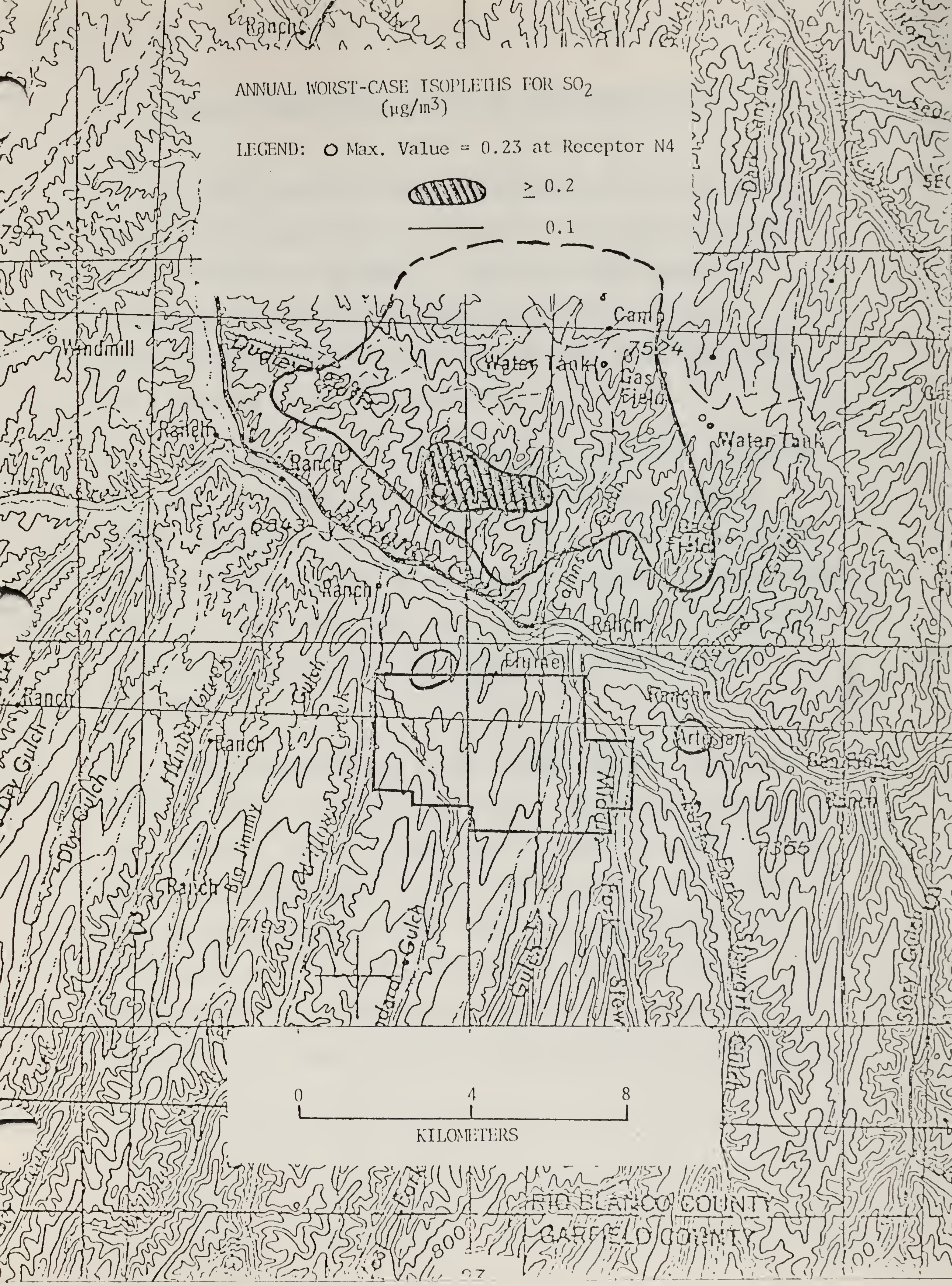
SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIG UN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1 GAS TREATMENT	453.74	62.13	25.	1.9000E-01	*********	0.	6740.	1202.	163.	152.	282.	478.	4.0	19.1
2 MINE VENT	460.00	60.00	88.	7.4300E+00	51.	0.	6820.	********	********	********	282.	284.	4.7	19.9
3 STEAM GENERATOR	458.40	60.00	52.	4.2000E-01	*********	0.	6820.	330.	92.	77.	282.	478.	1.6	15.4
4 TANK STORAGE	467.20	64.20	17.	4.3300E+00	3.	44.	6860.	********	********	********	282.	282.	120.0	1.0

ANNUAL WORST-CASE ISOPLETHS FOR SO_2

THE SO_2 CONCENTRATIONS AT EACH OF THE GROUND LEVEL RECEPTORS ON A 200 GRID SCALE WERE FOUND BY USING THE EPA VALLEY MODEL. ISOPLETHS WERE DRAWN BY INTERPOLATING BETWEEN THE RECEPTOR CONCENTRATIONS, ALLOWING FOR CHANGES IN ELEVATION BETWEEN RECEPTORS AND FOR LCATIONS OF POLLUTANT SOURCES.

THE CHART SHOWS 0.2 UG/M^3 AND 0.1 UG/M^3 ISOPLETHS FOR SO_2 CONCENTRATIONS RELATIVE TO THE C-B TRACT BOUNDARIES OVER AN ANNUAL AVERAGING TIME. THE HIGHEST CONCENTRATIONS OF SO_2 LIE IN THE HIGH GROUND NORTH OF PICEANCE CREEK. THIS SITUATION IS CAUSED BY PREDOMINATELY SOUTHWESTERLY WINDS BLOWING ACROSS THE PRINCIPLE SOURCE OF POLLUTANTS - THE GAS TREATMENT FACILITY - WHICH IS LOCATED ALONG THE NORTH BOUNDARY.

THE ISOPLETHS INDICATE ANNUAL WORST-CASE SO_2 CONCENTRATIONS WELL BELOW THE MAXIMUM ALLOWABLE ANNUAL SO_2 STANDARD OF 3.0 UG/M^3.



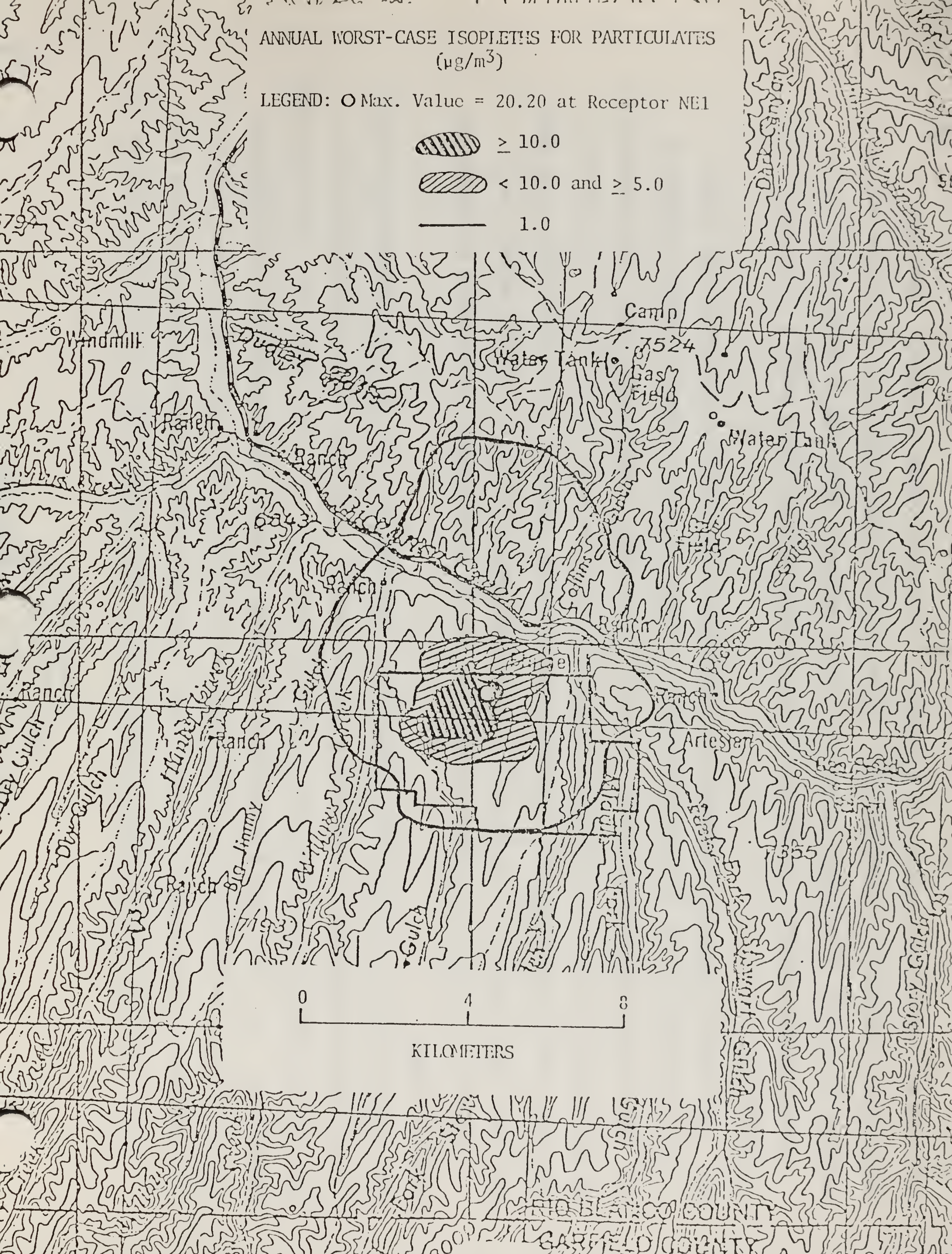
ANNUAL WORST-CASE ISOPLETHS FOR SO_2 ($\mu g/m^3$)

ANNUAL WORST-CASE ISOPLETHS FOR PARTICULATES

The particulate matter concentrations at each of the ground level receptors on a 200 grid scale were found by using the EPA Valley Model. Isopleths were drawn by interpolating between the receptor concentrations, allowing for changes in elevation between receptors and for locations of pollutant sources.

This chart shows 10.0 ug/m^3, 5.0 ug/m^3, and 1.0 ug/m^3 isopleths of particulate matter concentrations over an annual averaging time relative to the C-b Tract boundaries. The origin used in the calculation of receptor concentrations was at the mine vent and lies within the area exceeding the maximum allowable annual particulates concentration of 10 ug/m^3.

These isopleths are based on 160 acres of raw shale disposal area in Cottonwood Gulch. The disposal area is the principal source of fugitive particulate matter. It is shown in subsequent charts that reducing the disposal area to 80 acres results in a maximum concentration of 9.26 ug/m^3 which is below the annual averaging time standard of 10.0. The predominance of south and south-westerly winds carry the high concentrations to the north.


ANNUAL WORST-CASE ISOPLETHS FOR PARTICULATES
(μg/m3)
LEGEND: O Max. Value = 20.20 at Receptor NE1
≥ 10.0
< 10.0 and ≥ 5.0
1.0
0
4
8
KILOMETERS
Windmill
Camp
7524
Water Tank
Gas Field
Water Tank
Ranch
Ranch
Ranch
Ranch
Ranch
Ranch
Ranch
Ranch
Artesian
Gulch
Gulch
Big Jimmy
RIO BLANCO COUNTY
GARFIELD COUNTY
8000

PARTICULATE MATTER ENTRATIONS ANNUAL AVERAGING TIME (80% CONTROL)

PARTICULATE MATTER INCLUDES THOSE FROM POINT SOURCES (GAS TREATMENT, MINE VENT, AND STEAM GENERATOR) AND FROM FUGITIVE DUST FROM THE RAW SHALE DISPOSAL AREA. PARTICULATE MATTER CONCENTRATIONS BASED ON 160 ACRES RAW SHALE DISPOSAL AREA IN COTTONWOOD GULCH EXCEED ANNUAL AVERAGING TIME STANDARDS AT RECEPTORS NORTH OF THE DISPOSAL AREA. THIS CHART SHOWS A TABULATION OF THE ANNUAL AVERAGING TIME CONCENTRATIONS IN MICROGRAMS PER CUBIC METER AT RECEPTORS ALONG DIRECTIONS FROM NORTH TO EAST. THE FIRST TABLE SHOWS VALUES BASED ON 160 ACRES IN THE GULCH WITH 80% CONTROL AS DISCUSSED IN PREVIOUS CHARTS. THE RECEPTOR WITH MAXIMUM CONCENTRATION OF 20.2 UG/M^3 WAS THE NE 1 RECEPTOR USING 200 GRID SCALE. THIS RECEPTOR IS IN THE GULCH NEAR THE NORTH BOUNDARY OF THE C-B TRACT.

A STUDY OF THE EFFECT OF REDUCING THE ACREAGE OF THE RAW SHALE DISPOSAL AREA CONSISTED OF SUBTRACTING SUCCESSIVELY THE CONTRIBUTIONS OF TWO 40 ACRE AREA SOURCES FROM THE RECEPTORS WITH HIGH VALUES, NAMELY RECEPTORS 1 AND 2 IN EACH DIRECTION. THESE RESULTANT VALUES ARE TABULATED IN THE SECOND TABLE IN THE CHART. THE NORTH 40 ACRES IS THE FIRST AREA SOURCE SUBTRACTED AND THEN THE NEXT NORTH 40 ACRES TO REDUCE THE DISPOSAL AREA TO 120 AND 80 ACRES RESPECTIVELY. AS THE DISPOSAL AREA IS REDUCED TO 80 ACRES, THE CONCENTRATION OF PARTICULATE MATTER AT THE MAX RECEPTOR IS REDUCED TO 9.26 UG/M^3 WHICH IS BELOW THE ANNUAL STANDARD OF 10.0. THE VALUE OF 9.26 UG/M^3 IS REPORTED IN THE SUBSEQUENT CHARTS FOR THE ANNUAL PARTICULATE MATTER CONCENTRATION.

SOURCE FOR EMISSION RATE FOR THE RAW SHALE AREA IS BASED ON PEDCO REPORT NUMBER 9. FOR THE COARSE ORE AND SPENT SHALE PILES, THE EMISSIONS DEPEND ON A CLIMATE FACTOR (C) TAKEN HERE TO BE 60.0 RESULTING IN (UNCONTROLLED) EMISSIONS OF 8 TONS/ACRE/YEAR. THE REFERENCE CITES THAT 50% CONTROL OF FUGITIVE DUST IS ACHIEVABLE BY TWICE-PER-DAY WATERING AND 80% CONTROL IS ACHIEVABLE VIA USE OF CHEMICAL STABILIZERS.

PARTICULATE [illegible]ER CONCENTRATIONS
ANNUAL AVERAGING TIME
(80% Control)

160 ACRES IN COTTONWOOD GULCH							
	200 GRID RECEPTOR NUMBER						
DIRECTION	1	2	3	4	5	6	7
N	6.63	2.57	1.32	1.19	.84	.65	.50
NNE	13.01	4.13	1.78	1.23	.91	.71	.57
NE	20.20	2.77	1.36	.87	.73	.54	.42
ENE	9.79	1.78	.86	.64	.53	.38	.26
E	6.99	1.73	.83	.67	.45	.35	.26

REDUCED ACREAGES				
	120 ACRES		80 ACRES	
DIRECTION	1	2	1	2
N	4.65	1.79	2.67	1.01
NNE	7.99	2.59	2.98	1.05
NE	14.73	1.82	9.26	.87
ENE	7.48	1.28	5.17	.78
E	5.99	1.30	4.99	.87

SUMMARY OF WORST CASE COMPUTER INPUTS AND RESULTS

This chart provides the meteorological input data associated with the simulations that resulted in maximum concentrations shown in subsequent charts. The conditions were screened from the two years of environmental baseline data collected for the C-b Tract. Candidate worst-case meteorological conditions for each stability class were selected primarily on the basis of consecutive hours of persistence in each direction. Date, hours in the direction, wind speed at 30 feet elevation, ambient pressure, ambient temperature, and time of day were all tabulated for the candidate worst case condition. Four cases for each stability class were examined through the EPA Valley Model simulations and the worst case selected on the basis of receptor with maximum concentration. The 24 hour average concentration is computed by the model based on assumption of 6 hours persistence in a given direction and speed. Scaling of this average for persistences other than 6 hours was achieved by ratioing the concentration values by the actual direction persistence hours to 6 hours.

For averaging times other than 24 hour, the power-law ratio for averaging times recommended by EPA was used. This equation for 3 hour averaging time is:

$$X_3 = X_{24} \ (24/3)^{.44}$$

Other averaging times replace the 3 in the equation. For emission rates that are functions of averaging times, the X_{24} values were ratioed first by the emission rate ratio for the source and then the equation applied on a source by source basis.

In all simulations except the annual averaging time, mine vent plume rise was input as jet plume rise calculated by the Briggs equation:

$$\Delta H = 3.82v/DU$$

where: ΔH = plume rise (meters)
v = actual volume flow rate (meters^3/sec)
D = stack diameter (meters)
U - wind speed (meters/sec)

This equation was recommended for stack vent temperature that differs from ambient by less than 50°F which was the case for all mine vent worst case candidates. Mine vent temperatures were assumed to be 3.6°F above ambient temperature or 35°F, whichever was highest.

Nominal stack parameters are shown at the bottom of the table.

The high value for NOX is explained with the next chart. The standard for NMHC is based on 3 hour measurement times between 0600 and 0900. Only cases among the worst meteorological candidates that included these hours were considered with the worst case being a 3 hour period with B stability.

SUMMARY OF WORST CASE COMPUTER INPUTS AND RESULTS

Averaging Time	Pollutant	Stability Class	Date of Met Condition	Wind Direction	Wind Speed MPH	Duration of Cond. Hours	Mixing Height Meters	Mine Vent Plume Rise	Ambient Temp °F	Ambient Press mb	Grid	Receptor with Max. Conc.	Total Conc. ug/m³	Standard
Annual	SO_2	All	2nd Year Baseline	All	All	1 Year	1200	Model Calc.	34	782	200	N4	0.23	3.0
Annual	Part	All	2nd Year Baseline	All	All	1 Year	1200	Model Calc.	34	782	200	NE1	9.26	10.0
Annual	NOX	All	2nd Year Baseline	All	All	1 Year	1200	Model Calc.	34	782	50	ESE 1	27.6	100.0
24 Hour	SO_2	F	6-5-75	SSW	2.5	6	1200**	187.0	56	788	200	NNE 4	3.70	10.0
24 Hour	Part	D	2-7-75	SSW	24.2	24	1200***	15.7	45	781	50	NE 4	12.58	30.0
8 Hour	CO	A	5-6-76	SE	8.5	4	1200	55.0	41	790	50	NW 1	4949	10000
3 Hour	SO_2	F	6-5-75	SSW	2.5	6	1200**	187.0	56	788	200	NNE 4	14.75	75.0
3 Hour	NMHC	B	5-28-75	WNW	8.7	3	1200	56.5	56	788	50	ESE 3	2623*	160.0
1 Hour	CO	A	5-6-76	SE	8.5	4	1200	55.0	41	790	50	NW 1	13365	40000

NOTE: All runs used nominal stack heights and diameters

Nominal Stack Stack	Parameters Height	(Meters) Diameter
Gas Treatment	25.0	4.0
Mine Vent	88.4	4.7
Steam Generator	51.8	1.6

*See text (2597 background + 26 incremental)

** With F Stability, input mixing layer heights are changed to 10000 and ignored in the Valley Model.

*** With D Stability, the concentrations are calculated with .6 proportion at the input value and .4 proportion at one-half the mixing layer height input.

MAXIMUM POLLUTANT C[illegible]NTRATIONS
ANCILLARY FAC[illegible]ES
MICROGRAMS PER CUBIC METER

SHOWN HERE ARE THE MAXIMUM POLLUTANT CONCENTRATIONS AS DETERMINED THROUGH SIMULATIONS OF SOURCE AND WORST-CASE METEOROLOGICAL CONDITIONS. THE CONCENTRATIONS ARE IN MICROGRAMS PER CUBIC METER. THE PARENTHETICAL VALUES ARE THE FEDERAL AND STATE STANDARDS THAT ARE MOST RESTRICTIVE FOR THE POLLUTANT AND AVERAGING TIME. THE EMISSION RATES AND SOURCE PARAMETERS WERE SHOWN IN A PREVIOUS CHART.

THE SULFUR DIOXIDE VALUES ARE WELL BELOW THE STANDARDS FOR THE ANCILLARY FACILITIES. THE 9.26 MICROGRAMS PER CUBIC METER FOR PARTICULATE MATTER FOR ANNUAL AVERAGING TIME IS BASED ON EMISSION FROM THE THREE OIL SHALE PLANT STACKS AND FROM 80 ACRES OF EXPOSED RAW SHALE IN COTTONWOOD GULCH WITH 80 PERCENT CONTROL ACHIEVED THROUGH APPLICATION OF CHEMICAL STABILIZERS. THE PREDOMINANT WINDS ARE FROM THE SOUTH-SOUTHWEST WHICH CARRY THE PARTICULATE MATTER FROM THE RAW SHALE DISPOSED AREA INTO THE RECEPTORS JUST NORTH OF THE AREA. THE STANDARDS FOR 24-HOUR AND 3-HOUR AVERAGING TIMES ARE NOT EXCEEDED EVEN WITH 160 ACRES OF RAW SHALE EXPOSED IN COTTONWOOD GULCH. THE ANNUAL AVERAGING TIME IS THE CONTROLLING STANDARD FOR PARTICULATE MATTER. IT IS POSSIBLE, ALTHOUGH NOT COMPLETELY EXAMINED AT THIS TIME, THAT ADDITIONAL RAW SHALE DISPOSAL ACREAGE IN OTHER TRACT AREAS COULD BE UTILIZED CONCURRENTLY WITHOUT EXCEEDING STANDARDS.

THERE IS NO APPARENT PROBLEM IN COMPLYING WITH STANDARDS FOR CARBON MONOXIDE OR NITROGEN OXIDES. THE VALUES REPORTED INCLUDED BACKGROUND PEAK VALUES FROM BASELINE PLUS INCREMENTAL CONTRIBUTIONS FROM THE PROCESSING OPERATION.

THE NON-METHANE HYDROCARBONS (NMHC) VALUE OF 2623 MICROGRAMS PER CUBIC METER IS COMPOSED OF A BACKGROUND PEAK VALUE OF 2597 PLUS AN INCREMENTAL VALUE OF 26. ON THIS BASIS, THE 3-HOUR AVERAGING TIME STANDARD OF 160 IS EXCEEDED.

NUMEROUS VALUES IN EXCESS OF THE NON-METHANE HYDROCARBON "STANDARD" HAVE BEEN REPORTED DURING THE BASELINE PERIOD. ALTHOUGH THE INSTRUMENTATION FOR MEASUREMENTS OF HYDROCARBONS IN THE C-B TRAILERS IS REGARDED AS THE BEST THAT IS COMMERCIALLY AVAILABLE, IT IS DEFINITELY NOT REGARDED AS HIGHLY ACCURATE. FURTHERMORE, THE EPA DOES NOT, STRICTLY SPEAKING, REGARD THE VALUE FOR NMHC AS AN ABSOLUTE STANDARD; ITS VALUE WAS SET AT THE SAME LEVEL AS THAT FOR OXIDANT IN ORDER TO ASSIST IN KEEPING OXIDANT VALUES DOWN.

IN SECTION 3.2.1 OF THE ENVIRONMENTAL BASELINE FINAL REPORT AN ARGUMENT WAS SUPPORTED THAT ORIGINS OF NMHC AT THE TRACT, AT LEAST IN PART, ARE DUE TO TERPENES NATURALLY EMITTED FROM SAGEBRUSH. WIND DIRECTIONS ARE CONSISTENT WITH GENERAL DIRECTIONS OF THE UPLAND SAGEBRUSH COMMUNITY UPWIND OF STATION 023; STATION 020 IN PICEANCE CREEK VALLEY HAS MUCH LESS SAGEBRUSH UPWIND AND SHOWED LOWER BACKGROUND CONCENTRATION LEVELS.

THIS SAME REFERENCE REPORT DOCUMENTED THAT OZONE PRECURSORS WERE ALSO RESULTS OF LONG-RANGE TRANSPORT FROM EXTRA-REGIONAL URBAN CENTERS, OR STRATOSPHERIC STORM FRONTS OR BOTH.

RECENT EPA EMISSION-OFFSET POLICY STATEMENTS APPLY TO FUGITIVE DUST AND TO HYDROCARBON CONTROL PROGRAMS. HYDROCARBONS ARE PRECURSORS TO PHOTOCHEMICAL OXIDENT FORMATION AND THE LONG-RANGE TRANSPORT OF BOTH HAS BEEN ADDRESSED THEREIN. IN ESSENCE THE STATEMENTS SAY THAT HYDROCARBON CONTROL PROGRAMS ARE DEEMED TO BE NECESSARY WITHIN A RADIUS OF 85 MILES OF MAJOR URBAN AREAS AND "OFFSET" RESTRICTIONS ARE NOT NECESSARY IN RURAL AREAS.

THUS THE ANCILLARY FACILITIES MEET ALL AIR QUALITY STANDARDS WITH THE EXCEPTION OF THE NON-METHANE HYDROCARBONS; THEY A[illegible] NOT VIEWED AS A MAJOR PROBLEM FOR THE REASONS STATED ABOVE.

MAXIMUM POLLUTANT CONCENTRATIONS

ANCILLARY FACILITIES

MICROGRAMS PER CUBIC METER

AVERAGING TIME (STANDARD)	SO_2	PARTICULATES	CO	NMHC	NOX
ANNUAL	0.23 (3.00)	9.26* (10.00)	---	---	27.6 (100.00)
24 HOUR	3.70 (15.00)	12.58** (30.00)	---	---	---
8 HOUR	---	---	4949 (10000)	---	---
3 HOUR	14.75 (75.00)	---	---	2623*** (160.0)	---
1 HOUR	---	---	13365 (40000)	---	---

NOTES

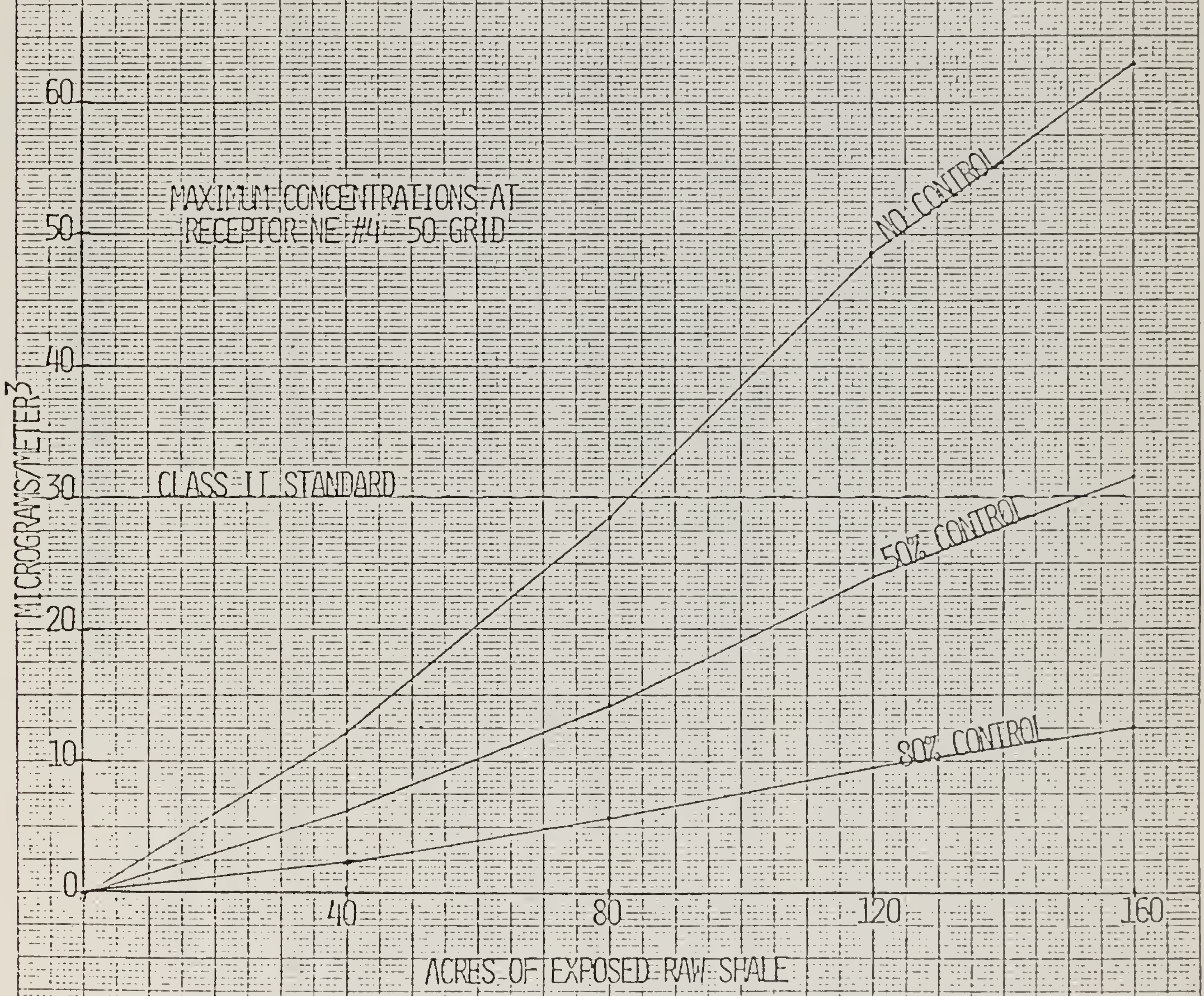
* BASED ON 80 PERCENT CONTROL AND 80 ACRES RAW SHALE EXPOSED

** BASED ON 80 PERCENT CONTROL AND 160 ACRES RAW SHALE EXPOSED

*** 2597 BACKGROUND + 26 INCREMENTAL

PARTICULATE CONCENTRATIONS
24-HOUR AVERAGING TIME

THIS CHART SHOWS A PLOT OF THE PARTICULATE MATTER CONCENTRATIONS VERSUS ACRES OF EXPOSED RAW SHALE IN COTTONWOOD GULCH FOR THE 24-HOUR AVERAGING TIME. THE CLASS II STANDARD IS 30 MICROGRAMS PER CUBIC METER. WITH NO CONTROL ON THE EXPOSED RAW SHALE THE ACREAGE MUST BE LIMITED TO 80 TO REMAIN BELOW THE STANDARD. WITH 50 PERCENT CONTROL, APPROXIMATELY 150 ACRES CAN BE UTILIZED FOR THE DISPOSAL AREA. WITH 80 PERCENT CONTROL ACHIEVED THROUGH APPLICATION OF CHEMICAL STABILIZERS THERE IS NO PROBLEM IN COMPLYING WITH THE 24-HOUR AVERAGING TIME STANDARD. THIS CONDITION WAS BASED ON WORST-CASE METEOROLOGICAL CONDITION OF D STABILITY, SSW WINDS WITH PERSISTENCE OF 24 HOURS, AND AVERAGE VELOCITY OF 24.2 MILES PER HOUR.



PARTICULATE CONCENTRATIONS
24-HOUR AVERAGING TIME

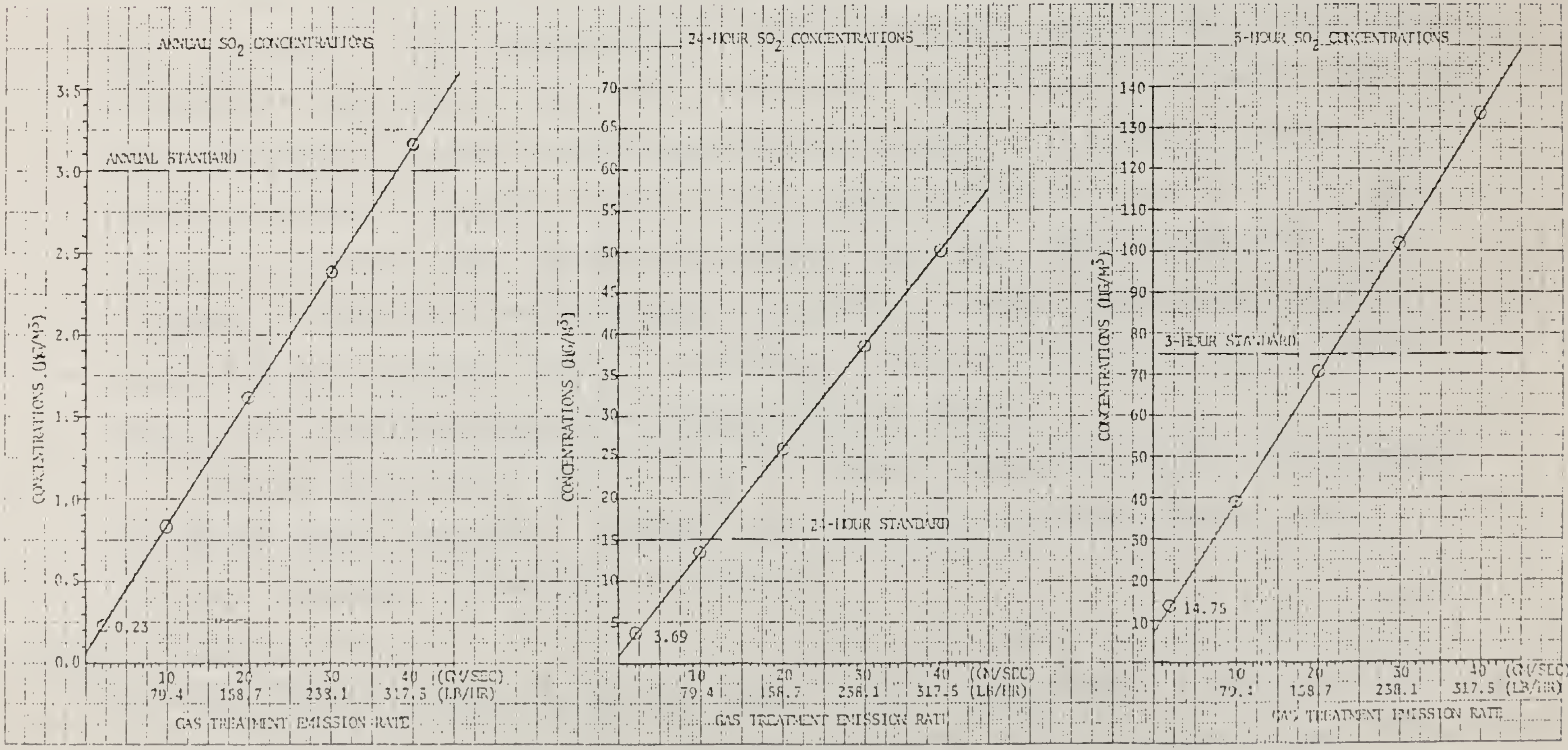
EFFECT OF GAS TREATMENT FACILITY SO_2 EMISSION RATE ON MAX CONCENTRATION

THIS CHART PROVIDES THE RESULTS OF A PARAMETRIC ANALYSIS OF THE GAS TREATMENT FACILITY SO_2 EMISSION RATE ON TOTAL SO_2 AMBIENT CONCENTRATIONS AT THE RECEPTOR WITH MAX WORST-CASE VALUES. THREE AVERAGING TIMES FOR WHICH STANDARDS EXIST WERE INCLUDED IN THE STUDY WITH RESULTS SHOWN.

THE Y-AXIS INTERCEPT ON EACH PLOT REPRESENTS THE CONCENTRATION DUE TO THE MINE VENT AND STEAM GENERATOR FACILITIES WITH NO SO_2 EMISSIONS FROM THE GAS TREATMENT FACILITY. THE FIRST POINT INDICATED ON EACH PLOT WITH TOTAL CONCENTRATION VALUES PRINTED ARE WITH THE GAS TREATMENT FACILITY EMISSION RATES SHOWN IN THE PREVIOUS CHARTS. WITH INCREASED SO_2 EMISSIONS FROM THE GAS TREATMENT FACILITY ONLY, THE TOTAL CONCENTRATION EXPECTED AT THE RECEPTOR WITH MAX CONCENTRATION IS SHOWN AS A FUNCTION OF GAS TREATMENT FACILITY EMISSION RATE. THE SO_2 STANDARDS FOR EACH AVERAGING TIME ARE ALSO SHOWN ON THE PLOTS.

TO COMPLY WITH THE MOST CRITICAL STANDARD (24-HOUR), EMISSIONS FOR THE IN-SITU OFFGAS TREATMENT FACILITY CAN INCREASE TO THE H_2S EQUIVALENT VALUE OF 83 PPMV FROM 15 PPMV.

EFFECT OF GAS TREATMENT FACILITY
SO_2 EMISSION RATE ON MAX CONCENTRATION



EMISSIONS OF HAZARDOUS ELEMENTS

Calculations have been made of incremental ground level concentrations of mercury and arsenic for <u>full-scale</u> operations. These values have then been compared with 1/30 of the appropriate Threshold Limit Values to determine if they fall within acceptable limits, in accord with Colorado Air Quality Regulation No. 8.

It was assumed in these calculations that the dilution factor between the stack and the ground is that corresponding to dilution of 174 lb/hr[1] of SO_2 at the stack to 15 ug/m^3 on the ground at the point of maximum impact (24-hour standard). With this dilution factor, neither mercury nor arsenic is expected to exceed allowable limits. Mercury compounds could be emitted at rates ranging from twice to ten times those expected, depending upon the specific mercury compound. Arsenic compounds could likewise be emitted at rates ranging from seven to fifteen times those expected, again depending upon the specific compounds. Other details pertaining to mercury and arsenic emissions are shown in the following tables.

Similar calculations will be made for selenium when data on its concentration in offgas become available. Judging from the calculations for arsenic, which selenium resembles, no problem is expected.

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1 174 lb/hr of sulfur dioxide from offgas burning corresponds to scrubbing the offgas down to an equivalent H_2S concentration of 15 ppmv before burning. If sulfur in the offgas exceeds this value, the dilution required will be greater and affort more latitude for trace element emissions.

MERCURY EMISSIONS (FULL-SCALE OPERATIONS)

ASSUMPTIONS:

0.43 PPM HG IN SHALE, BY WEIGHT.[1]

58% OF HG IN SHALE ENDS UP IN GASEOUS PRODUCTS.

DILUTION IS ADEQUATE FOR THE 24-HR SO_2 STANDARD.

ALLOWABLE INCREMENT TO GROUND LEVEL CONCENTRATION IS 1/30 OF THE THRESHOLD LIMIT VALUE, COLORADO AIR QUALITY REGULATION NO. 8.

RESULTS:

0.25 PPM OF THE HG (BY WEIGHT) ENDS UP IN THE OFFGAS.

DAILY PRODUCTION OF HG IS 48 LB.

CONCENTRATION OF HG IN THE BOILER EXHAUST IS 0.027 PPMV.

DILUTION RESULTS IN GROUND LEVEL CONCENTRATIONS OF 0.00083 UGMOLE/M^3.

THE MOST STRINGENT ALLOWABLE GROUND LEVEL CONCENTRATION IS 0.00166 UGMOLE/M^3 (BASED ON ALKYL MERCURY COMPOUNDS).

CONCLUSION:

MERCURY EMISSIONS ARE WITHIN ALLOWABLE LEVELS.

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1 DONNELL, J.R., AND SHAW, V. E., "MERCURY IN OIL SHALE FROM THE MAHOGANY ZONE OF THE GREEN RIVER FORMATION, EASTERN UTAH AND WESTERN COLORADO," J. RES. U. S. GEOL. SURV., 5, NO. 2, MARCH-APRIL 1977, 221-26.

ARSENIC EMISSIONS (FULL-SCALE OPERATIONS)

ASSUMPTIONS: ARSENIC IN THE OFFGAS DOES NOT EXCEED 2 PPM BY WEIGHT IN THE ORGANIC FRACTION (BASED ON ARSENIC ANALYSES IN FISHER ASSAY PRODUCTS).

DILUTION IS ADEQUATE FOR THE 24-HR SO_2 STANDARD.

ALLOWABLE INCREMENT TO GROUND LEVEL CONCENTRATION IS 1/30 OF THE THRESHOLD LIMIT VALUE (COLORADO AIR QUALITY REGULATION NO. 8).

RESULTS: THE ARSENIC IN THE BOILER EXHAUST IS 0.52 PPM BY WEIGHT.

THE ALLOWABLE EMISSION RATE FOR THE MOST STRINGENT INCREMENT TO GROUND LEVEL CONCENTRATION IS 7.9 PPM BY WEIGHT (BASED ON ARSINE).

CONCLUSION: ARSENIC EMISSIONS ARE WITHIN ALLOWABLE LEVELS.

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2. Briggs, Gary A.: Plume Rise from Multiple Sources. Published in Cooling Tower Environment - 1974. Proceedings of a Symposium held at the University of Maryland Adult Education Center, March 4-6, 1974. ERDA Symposium Series 35. 1975. pp. 161-179.

3. Donnell, J.R., and Shaw, V.E., "Mercury in Oil Shale from the Mahogany Zone of the Green River Formation, Eastern Utah and Western Colorado," J. Res. U.S. Geol. Surv., 5, No. 2, March-April 1977, 221-16.

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5. TVA: Full-Scale Study of Plume Rise at Large Electric Generating Stations. Tennessee Valley Authority, Division of Health and Safety, Muscle Shoals, Alabama, September 1968.

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8. Turner, D. Bruce: Workbook of Atmospheric Dispersion Estimates. U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1970. NTIS PB-191482. 84 pp.

C·b Shale Oil Venture

2372 G Road — P.O. Box 2687
and Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

June 28, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
U.S.G.S. Conservation Division
Mesa Federal Savings & Loan
131 N. 6th, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

We are sending you the following items as additional information for Section V-A of the DDP Modification:

1. Air Pollution Control Plan

2. Estimate of Mercury Emissions.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason

R. E. Thomason
Manager, Leasehold Development

RET:pmr

Attch.

cc: J. J. Hill
R. A. Loucks
R. J. Fernandes

AIR POLLUTION CONTROL PLAN
FOR TRACT C-b

Introduction

The air pollution concerns during the development and operation of Tract C-b are (1) dust from roads, from construction, from the handling of raw shale, and from the raw shale dump; (2) pollutant emissions from mining; (3) pollutant emissions from the ancillary retorting unit; and (4) pollutant emissions from the full-scale retorting operation. Pollutants of concern are sulfur compounds, carbon monoxide, hydrocarbons, particulates, and oxides of nitrogen. Measures to be used in controlling these pollutants are described below.

Before proceeding to a description of the pollution control measures, it should be noted that tall stacks will be used to disperse the pollutants (except dust originating at ground level). Plume rise calculations and dispersion modeling for various exhausts are reported in transmittals to the Area Oil Shale Office dated June 15, 1977. Further reference will not necessarily be made here to such dispersion, but it should be kept in mind when interpreting the information presented here. Also, please note that the expected emissions for the various operations have also been previously tabulated and submitted to the Area Oil Shale Office.

Dust Control

Dust will be controlled on the main access road by paving it. Dust on other roads will be controlled by wetting down, oiling, or the use of palliatives, depending upon the intensity of use and the severity of the problem.

Dust in handling raw shale will be minimized by virtue of the shale being moistened when coming from the mine. The raw shale dump will be moistened or have a dust control agent applied and will be vegetated to control fugitive dust. The amount of exposed acreage will be restricted to avoid significant deterioration of air quality from fugitive dust.

Mine Exhaust

Air coming from the mine will be cleansed of particulates by passing through a bag house or by some alternative means such as electrical precipitation. Prior to such cleansing, about 80% of the dust in the air will have settled out in the mine.

If diesel equipment is used in mining, its exhaust will be catalytically scrubbed. Noxious gases from periodic blasting will be exhausted without control; their dispersion from the stack is adequate to keep ground level concentrations within acceptable levels.

Ancillary Operations

The ancillary operation has two exhausts in addition to the mining exhaust: the burned retort offgas exhaust and the steam boiler exhaust. The retort offgas will be treated to remove sulfur compounds before it is thermally oxidized. If organic sulfur compounds are sufficiently low in concentration, then the treatment will be with the Stretford of similar process to remove hydrogen sulfide. If organic

sulfur compounds are too abundant (in terms of the sulfur dioxide they would form), they will be removed by other appropriate equipment such as an alkaline scrubber, e.g. monoethanolamine (MEA) and then caustic. Such a treatment will also remove hydrogen sulfide and thereby reduce or eliminate the need for Stretford processing. Carbon dioxide may be removed with a hot potassium carbonate process before treating the gas with monoethanolamine in order to avoid loading the MEA with CO_2. In any event the equipment selected would employ best available commercial control technology to hold emissions below regulatory limits.

Burning the retort offgas will convert carbon monoxide and hydrocarbons to carbon dioxide and water. Particulates will be at very low levels. Residual sulfur compounds (i.e. after the cleaning described above) will be converted to sulfur dioxide. Oxides of nitrogen will be kept to a minimum by keeping the flame temperature down by using adequate excess air. All pollutants will thus be at sufficiently low levels that they can be adequately dispersed by exhausting through a tall stack.

The steam boiler will burn very low sulfur fuel (<0.025%S by wt.). Its flue gas will be exhausted through a tall stack without treatment.

Full-Scale Retort Operations

The main differences between the full-scale operation and the ancillary operation described above are the scale of the operation and the fact that steam will ordinarily be generated by burning the offgas. Thus, there will ordinarily be only one process exhaust stack, which releases burned retort offgas. This gas will be treated before burning, as described above. The boiler will be fired with low sulfur fuel, as above, whenever retort offgas is not sufficient, e.g. start-up conditions and upsets or emergencies.

Upset Situations

In the event of retort upsets, exhaust air flows can nevertheless be maintained. This will enable the reduced amounts of pollutants to be adequately dispersed so that air quality is not significantly degraded.

There will be some spare capacity in the gas handling facilities, which will be modularized. Thus, one or two modules can be out of commission without impairing the overall gas handling capacity. If, however, the working capacity of the gas facilities is less than that required by the number of retorts that are operating, then one or more retorts can be banked until the necessary facilities are back on stream.

Note: Burned retort offgas and boiler exhausts will be hot (ca. 400°F). The mine exhaust will be jetted out (ca. 30 m/sec.). Thus, plume rises will be significant.

19 May 1977

To: R. E. Thomason

From: A. M. Rusk

Subject: Mercury Emissions to the Atmosphere

I have estimated our mercury emissions and compared them with allowable levels. The emissions were estimated on the basis of a recent paper by John Donnell and Van Shaw of the U.S.G.S. The allowable levels were determined from Colorado Air Pollution Control Regulation No. 8. The conclusions are (1) our predicted emissions are one half the allowable emissions if all the mercury is in the form of alkyl compounds, and (2) our predicted emissions are one tenth the allowable emissions if none of the mercury is in the form of alkyl compounds.

My calculations and Donnell's and Shaw's article are attached.

P.S. Donnell and Shaw show that 2% of the initial mercury remains in the spent shale. Between 15% and 16% goes into retort water (water from the retorting reaction). Twenty-five per cent goes into the oil. And 58% goes off in the gas.

cc: G. E. Fosdick
J. J. Hill

Ame
P. 1 of 3

Mercury Emissions

Ref.: Donnell, J.R., & Shaw, V.E., "Mercury in Oil Shale from the Mahogany Zone of the Green River Formation, Eastern Utah and Western Colorado," J. Res. U.S. Geol. Surv., 5, No. 2, Mar.-Apr. 1977, 221-26.

Test hole nr. C-b: 0.43 ppm Hg in shale.
58% ends up in gaseous products.
⇒ 0.25 ppm Hg in gas (based on shale wt.)

Daily production of Hg in gaseous products:

25 gpt & 57,000 bpd ⇒ 95,798 tons/day
(0.595 bpt)

$(95,798)(0.25 \times 10^{-6})$ = 0.0239 tons Hg / day in gas
= 48 lb/day Hg in gas

Daily gas flow rate: 2.2×10^{6} scfm boiler exhaust
$3,168 \times 10^{6}$ scfd. " "

$48 \text{ lbs} / 3.168 \times 10^{6} = 1.5 \times 10^{-8}$ lb/scf.

$= 7.5 \times 10^{-11}$ lb-moles/scf.

⇒ Hg concentration = 2.7×10^{-2} ppm in boiler exhaust

Dilution factor for boiler exhausts:
(if controlled by 24-hr SO_2 limits)

$$\frac{181 \text{ lb/hr } SO_2}{64 \text{ lb/mole } SO_2} = 2.83 \text{ lbmole/hr } SO_2 \text{ emitted}$$

Max. ground level conc: $15\ \mu g/m^3 / 64$ g-mole $= 0.234\ \mu$gmole SO_2/m^3

Dilution: 2.83 lb-mole/hr $/ 0.234\ \mu$gmole$/m^3$

Apply to Hg emissions:

48 lb/day = 2 lb/hr. = 0.01 lb-moles/hr.

Ground level conc:

$$\frac{0.234\ \mu g\text{-mole}/m^3}{2.83 \text{ lb-mole/hr}} \times 0.01 \text{ lb-mole/hr} = 8.3 \times 10^{-4}\ \frac{\mu g\text{mole}}{m^3}$$

Allowable Ground Level Increment: Colo. Reg. No. 8:

$$(1/30)(0.01\ mg/m^3) = 3.33 \times 10^{-4}\ mg/m^3 = 1.66 \times 10^{-6}\ \frac{mg\text{moles}}{m^3}$$

(alkyl Hg. cmpd's

$$= 1.66 \times 10^{-3}\ \frac{\mu g\text{moles}}{m^3}$$

$$\frac{\text{Predicted ground level conc.}}{\text{Allowable ground level conc.}} = \frac{8.3 \times 10^{-4} \mu g\,mole/m^3}{1.66 \times 10^{-3} \mu g\,mole/m^3} = 0.5$$

That is, the predicted level is ½ the allowable level. (Providing the SO_2 24-hr. limit governs and is used as above.)

If the mercury is in a form other than alkyl mercury compounds, then 5 times the above allowable ground level conc. applies. In this case, the predicted level is only 1/10 the allowable level.

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Jour. Research U.S. Geol. Survey
Vol. 5, No. 2, Mar.-Apr. 1977, p. 221-226

MERCURY IN OIL SHALE FROM THE MAHOGANY ZONE OF THE GREEN RIVER FORMATION, EASTERN UTAH AND WESTERN COLORADO

By JOHN R. DONNELL and VAN E. SHAW, Denver, Colo.
303/234-5114 303/234-2450

Abstract.—Mercury has been reported in concentrations as ch as 4 parts per million from oil shale in the Green River rmation near the Federal oil-shale prototype lease-tracts n and U-b in eastern Utah. This high concentration of ercury if present throughout a minable zone, would be of ncern in commercial oil-shale operations processing large lumes of shale. Using an improved analytical method, sur-e samples from eastern Utah previously reported to con-n high concentrations of mercury were reanalyzed, and an ditional 183 drill core samples from the Mahogany zone d adjacent beds were analyzed. The reanalyzed samples eraged slightly more than 0.35 ppm mercury and the drill-re samples averaged 0.37 ppm. The products from a Fischer say of 100-gram sample of oil shale, found to yield 35 gal-s per ton of oil and 43 ppm of mercury, were analyzed for ir mercury content. The spent shale contained only 2 per-nt of the total mercury in the assay products and the gas ction contained about 58 percent.

Project Independence blueprint gives several ...ies for the development of oil-shale (U.S. Fed-l Energy Administration, 1974, p. 60). Under mini-un production, 50,000 bbl (barrels) of oil a day will produced from oil shale in 1980, increasing to 750,-) bbl a day by 1990.[1] The most optimistic projection stulates a production of 200,000 bbl of oil a day in 0, increasing to 2.5 million barrels a day by 1990. en under the most conservative projection of pro-ction, large quantities of oil shale may be mined and cessed by the year 1990. Because of the large vol-e of material being processed, metals such as mer-y, though present in very minor quantities in the le, may have an effect on the environment. The ount of these trace metals and their ultimate dis-ition during and after processing of the shale is importance.

f a large part of the mercury present in oil shale rs the gas fraction of retorted shale, the mercury y be washed from the atmosphere into streams or y be absorbed by vegetation. It might then travel ough the food chain to the grazing animal and ultimately into the human system. Mercury contained in the water produced from the shale in the retorting process will pose a similar hazard to streams and vegetation. Mercury in the oil produced from the shale presumably will be present in quantities no greater than those in most crude oils. Mercury that remains in the retorted residue may be fixed in the inorganic fraction or in the remaining organic carbon, or it may be leached from the tailings and enter the ecosystem.

Four tracts of Federal land in Colorado and Utah totaling slightly more than 20,000 acres (8,100 hectares) were leased in 1974 under the U.S. Department of the Interior's prototype oil-shale leasing program. The potential total productive capacity of these tracts is in excess of 300,000 bbl of oil a day for a period of at least 20 years. Under the terms of the lease the lessees are required to monitor the environment for a period of at least 1 year prior to submitting a final development plan. Core obtained from exploratory drilling, which is part of the monitoring process, is analyzed for trace elements, including mercury. Trace-element analyses done by the lessees are on composite samples from fairly thick oil-shale intervals not necessarily related to minable units.

Core samples from hole C–176 (fig. 1), which penetrated the Mahogany zone, were selected by us for detailed mercury analysis. Core-hole C–176 is southeast of prototype oil-shale test-lease tract C–b.

PREVIOUS WORK

Thus far a systematic analysis of oil shale for mercury has not been undertaken. In 1959 R. A. Cadigan of the U.S. Geological Survey collected eight samples from an 800-foot (244-metre) interval in the Green River Formation in eastern Utah, and had them analyzed for mercury. The samples came from the outcrop in Hells Hole Canyon, sec. 17, T. 10 S., R. 25 E., about 1 mile (1.6 kilometres) east of the east edge of the prototype lease-tract U–b. The analysis indicated a maximum of 4.0 parts per million mercury from the

[1] To convert barrels (1 bbl=42 gal) to cubic metres, multiply by ...0; to convert gallons per ton (2,000 lb) to litres per metric ton ...) multiply by 4.16.

2372 G Rood – P.O. Box 2687
Grond Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shole, Inc.
Operotor
Ashlond Colorado Inc.

April 1, 1977

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APR 1 1977
OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

Mr. Miles D. LaHue
Area Oil Shale Office
Mesa Federal Building
131 No. 6th Street, Suite 300
Grand Junction, Colorado 81501

Dear Mr. LaHue:

We recently answered your request for comments on the proposed "Minimum Guidelines for Detailed Development Plans: Air Pollution Control Plans and Related Modeling Analyses." At that time, I indicated that we would soon be responding to specific questions in the guidelines, and I would like to do so now.

All but two issues raised in the proposed guidelines are addressed in either the original Detailed Development Plan, the November 1, 1976 DDP supplement on air quality, or the Modification to the DDP that we submitted a few weeks ago. The two issues not previously addressed are (1) provisions for start-up and upset conditions, and (2) potentially hazardous emissions; both are discussed in this etter.

Start-Up and Upset Conditions. From the standpoint of air pollution control, the significant aspects of start-ups and upsets are (1) the possibility that the off-gas flow rate will be too low for good pollutant dispersion under these conditions, and (2) the possibility that either the Stretford plant or a boiler or thermal oxidizer will malfunction.

The off-gas flow rate is itself not the critical flow; rather the critical flow is the stack flow rate. If fewer retorts are in use than called for in the final design, the stack flow rate can nevertheless be sustained by continuing to supply the necessary volume of air to the stack directly from the blowers. This will keep the exit velocity up and thereby help disperse the exhaust pollutants. Such a practice will lower the exhaust temperature somewhat, but counterbalancing this effect is the fact that there will also be a smaller amount of pollutants to disperse. Incidentally, this approach will not violate the regulation against dilution to meet emission limitations. We will already be far below the emission limits, so dilution is not being used to meet the limits.

The Stretford plant that removes hydrogen sulfide from the off-gas will be modularized. Part of the plant can be out of commission without causing the whole plant to be down. A measure of excess capacity can also be provided to take care of cases where just one or two modules are out. Also, a fraction of the operating retorts can be temporarily banked if necessary in order to match the input to the Stretford plant with its active capacity.

The boilers or thermal oxidizers will also be modularized so that a segment can be down without putting the whole plant out of commission. As before, if the active capacity of these units is less than required by the retort off-gas, then

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some of the retorts can be banked until the active capacity is adequate.

<u>Potentially Hazardous Emissions</u>. The only potentially hazardous emissions that we can imagine are hydrogen sulfide and possibly arsenic and arsine. Hydrogen sulfide will be stripped from the off-gas down to 15 ppmv or less in the Stretford plant; this residue will be converted to sulfur dioxide when the off-gas is burned. Thus, hydrogen sulfide will not be emitted to the atmosphere. (See also the above discussion on upsets.).

We are not sure just what levels of arsenic or arsine will occur in the exhaust, but we know that arsenic accumulates preferentially in asphalts and other heavy ends of the product oil. Light fractions, i.e. those with boiling points less than 375°F, contain less than 2 ppm arsenic by weight. If we assume that the arsenic content in the organic fraction of the off-gas also does not exceed 2 ppm by weight, then we can determine if this amount constitutes a hazard in the exhaust. Calculations to this end are attached.

As shown in the calculations, the allowable emission rate for arsenic is more than 35 times the maximum expected emission rate. The allowable emission rate is also more than 15 times the maximum expected emission rate for arsine (if all the arsenic were in the form of arsine). Thus, the maximum expected emissions of arsenic and arsine are far below what is allowable. No hazard from these materials is anticipated.

Please contact us if you have any questions on these issues.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason
Manager, Leasehold Development

RET:pmr

cc: G. E. Fosdick
J. J. Hill
R. A. Loucks
R. J. Fernandes

Attch.

EVALUATION OF ARSENIC AND ARSINE HAZARDS IN THE C-b EXHAUST

Evaluation of potential arsenic and arsine hazards in the C-b exhaust is based on comparing expected emissions with allowable emissions. The calculational procedure is described below, and the calculations are attached.

First, the maximum expected weight fraction of arsenic in the off-gas is converted to the maximum expected weight fraction of arsenic in the exhaust. Two ppm by weight in the organic fraction of the off-gas is equivalent to 0.52 ppm by weight in the exhaust.

Second, the allowable concentrations of arsenic and arsine at ground level are calculated on the basis of Colorado Air Quality Control Regulation No. 8. This regulation limits ground level concentrations of a pollutant to 1/30 of its Threshold Limit Value (TLV), i.e. 0.5 mg/m^3 for arsenic and 0.2 mg/m^3 for arsine. The ground level concentration limits for arsenic and arsine are thus 17 $\mu g/m^3$ and 7 $\mu g/m^3$, respectively.

Third, the allowable ground level concentrations are then converted to allowable emission rates by using the dilution factor for the stack exhaust. The dilution factor is determined by knowing that the stack must be such that sulfur dioxide is diluted from 8 ppmv to 15 $\mu g/m^3$ 24-hour average), which is the most demanding dilution requirement. (Note: All effects are converted to moles and then converted back to concentrations by weight or volume as required.) The allowable emission rates are 19.5 ppm by weight for arsenic and 7.9 ppm by weight for arsine.

Finally, the allowable emission rates and the maximum expected emission rates are compared to determine if there is a potential problem. Thirty-five times more arsenic and fifteen times more arsine could be emitted than is expected without violating Regulation No. 8.

AMR

3-25-77

C·b Shale Oil Venture
2372 G Rood — P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

April 11, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
Mesa Federal Savings & Loan Bldg.
131 N. 6th - Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

Attached is a revision of Table V-A for the C-b DDP Modification. This table incorporates estimates for emissions from the mine vent and the shaft disposal pile that were overlooked in preparing the table initially.

The addition of these sources does not materially affect the conclusion, i.e. the emissions of the revised scheme do not require stacks beyond the realm of reason. With the exception of carbon monoxide and the 3-hour sulfur dioxide emissions, all emissions from the revised scheme are less than those of the original DDP. The carbon monoxide situation is not critical because neither the one-hour or eight-hour standard is really threatened; see table footnote #12. The 3-hour sulfur dioxide emission is less than five times the 24-hour emission. Thus, it will fall within the appropriate standard when the stack is designed for the 24-hour standard; see footnote #10.

The assumptions incorporated in these estimates are cited in the footnotes to the table. The table also incorporates the narrative appearing in the DDP modification.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason
Manager, Leasehold Development

RET:pmr

cc: G. E. Fosdick
J. J. Hill
R. A. Loucks
R. J. Fernandes
A. M. Ruskin

FULL-SCALE EMISSIONS, lb/hr

Pollutant	Averaging Time	In-Situ Process[1]	Mine Vent[2,3,4]	Shale Disposal	Tank Storage	Total	Original DDP[5]
Particulates	24 hr	<74	16[6]	44[7]	-	<134	361
	Annual	<74	15[6]	44[7]	-	<133	
SO_2	3 hr	174[8]	237[9]	-	-	411[10]	
	24 hr	174[8]	37[9]	-	-	211[10]	251
	Annual	174[8]	15[9]	-	-	189[10]	
CO	1 hr	84	19,140[11]	-	-	19,224[12]	
	8 hr	84	2,450[11]	-	-	2,534[12]	
	Annual	84	257[11]	-	-	341	511
THC	3 hr	15	59[13]	-	103[14]	177	353
	Annual	15	12	-	103[14]	130	
NO_x	Annual	588	300[15]	-	-	888	1,996

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1 In situ emissions are estimated from the combustion of the off-gas. Estimates are made from EPA AP-42 in proportion to higher heating values for gaseous fuels (used by EPA on page 1.5-2). No fuel burning above the combustion of off-gas is needed for power or heat.

2 Emission rates from the mine vent depend heavily on the amount of time over which the reaction products from a rubbling blast are averaged.

. . . continued

3 Rubbling is assumed to occur not more than once per 24-hour period and not more than 70 times per year.

4 It is assumed that 7,000 gallons of diesel fuel are burned underground daily. Diesel emissions are estimated from EPA AP-42, p. 3.1.5-2.

5 Figures for the original DDP plant design are from a report to the Area Oil Shale Supervisor dated 1 November 1976.

6 Crushing is estimated to produce 0.5 lb. of particulates/ton of shale blasted; see EPA AP-42, Table 8.20-1. Blasting is estimated to produce no more particulates than crushing. Handling and hauling are estimated to produce no more particulates than four times the amount produced on crushing. Eighty per cent of the particulates produced are assumed to settle out in the mine (EPA AP-42). Collection efficiency of the balance is estimated at 99%. Five per ce of the particulates formed in rubbling are assumed to escape from the retort into the mine.

7 The maximum acreage of raw shale exposed at any one time is estimated to be 150 acres. If emissions were uncontrolled it is estimated that they would b 8 tons/acre/yr. Control of fugitive dust emissions from shale disposal operations is estimated to be 80%.

8 The Stretford plant is assumed to emit 15 ppmv H_2S maximum.

9 ANFO is assumed to be the explosive used in mining and rubbling. Fuel oil with 1.2% sulfur is assumed.

10 In the original DDP, the controlling SO_2 standard was the Colorado 24-hour allowable increment of 15 μg/m^3. This figure is one fifth the 3-hour standard of 75 μg/m^3. Thus, the 3-hour emission rate can probably range up to five times the 24-hour emission rate without requiring a taller stack.

11 Blasting is assumed to produce 0.04 lb of CO per lb of ANFO, due to non-ideal reaction behavior. Rubbling produces 18,800 lb of CO once every 5 days.

12 For pollutant dilution adequate for SO_2 dispersal, the estimated ground level concentrations of CO are 2174 μg/m^3 for 1-hour averaging times and 190 μg/m^3 for 8-hour averaging times. These numbers are significantly less than the corresponding standards of 40,000 μg/m^3 and 10,000 μg/m^3.

13 It is assumed that 0.5% of the fuel oil in ANFO is not burned in blasting and comes out the mine vent as hydrocarbons.

14 The figures for losses from "tank storage" also include losses from handling product oil, whether stored or not. Storage of five days' production is assumed. Storage losses are estimated to be 0.0052 lb/day/1000 gallons and working losses are estimated at 1.0 lb/1000 gallons throughput (EPA AP-42, pp. 4.3-8,9).

15 Blasting is assumed to produce 0.04 lb of NO_2 per lb of ANFO, due to non-ideal reaction behavior.

Z AQ-2

C·b Shale Oil Venture

2372 G Road — P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

RECEIVED

APR 18 1977

OFFICE OF
AREA OIL SHALE SUPERVISOR
U.S. G.S.

April 15, 1977

Mr. Eric Hoffman
Area Oil Shale Office
Mesa Federal Savings Building
131 North Sixth Street, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Hoffman:

You asked for a summary of the sources of oxides of nitrogen for the original DDP for Tract C-b and for the DDP Modification. Accordingly, I list below the annual hourly emissions of NO_x for the two schemes.

Original DDP

Mine vent	250 lb/hr
Pyrolysis preheater	1,479
Pyrolysis elutriator	126
Coker furnace	9
Hydrolysis feed preheaters	5
Hydrolysis unit reboilers	12
Hydrogen reform. furnace	90
Utility boilers	24
Total	1,995 lb/hr

DDP Modification

In-situ off-gas combustion	588 lb/hr
Mine vent	300
Total	888 lb/hr

The two mine vents produce comparable amounts of NO_x on an "annual average" basis. The major difference, therefore, is due to process differences, not mining differences.

We have learned that one must be rather careful in responding to questions about sources of NO_x. The temperature of retorting and the temperature of combustion must be distinguished if the process is one of direct combustion. If the process is indirect, the fact that there is a

separate, high temperature fired unit must be pointed out. And whether retorting is done with an oxidizing or reducing atmosphere must be noted.

Thus, the answer to Mrs. Wright's question at the Oil Shale Environment Advisory Panel meeting should have explained that the TOSCO process uses an external high temperature fired unit with an oxidizing atmosphere, whereas the Occidental process uses a lower combustion temperature and a reducing atmosphere in a direct combustion process. The retorting temperature per se is not the issue. What NO_x is produced in the Occidental process comes from subsequent combustion of off-gas in an oxidizing atmosphere; this is less than is produced in the external fired units of the TOSCO process.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason

R. E. Thomason
Manager, Leasehold Development

RET:rp

cc: A. M. Ruskin
R. A. Loucks
R. J. Fernandes
J. J. Hill
G. E. Fosdick

C·b Shale Oil Venture

2372 G Road — P.O. Box 2687
Grand Junction, Colorado 81501
(303) 242-8463

Occidental Oil Shale, Inc.
Operator
Ashland Colorado Inc.

June 16, 1977

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
Mesa Federal Savings Building
131 North Sixth Street, Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

Pursuant to our discussion in your office on June 2, 1977, I am submitting additional information on plume rises for C-b's full-scale operation. This information further substantiates the claim in my letter of February 9, 1977, that the plumes for the modified in situ process will rise as much or more than the plumes envisioned in the original DDP. Since our projected total pollutant amounts are less than those projected in the original DDP, it is clear that the stack height determined for the original DDP is adequate for our case as well, providing of course that we locate our stack similarly to theirs. The stack locations for the two cases are indeed similar, i.e. near the high part of the center of the tract, so the comparison is valid.

The plume rises calculated for process units in the original DDP range from 96 to 107 meters for nominal wind speeds, depending upon the particular process unit. The plume rise calculated for our process unit ranges upwards from 298 meters, depending upon mean wind speed. The value of 298 meters corresponds to a mean wind speed of 15 meters per second (33.6 mph). At lower, more typical mean wind speeds, e.g. 2 meters per second, the plume rise is on the order of 2,200 meters. This large rise occurs, of course, because of the high volume and temperature of the gas. In any event, there should be no doubt that the plume rise from the process unit of our proposed plant exceeds the plume rises from process units in the original DDP.

The mine vent in the original DDP was not reported to contain sulfur dioxide and was not considered in the modeling presented in support of the original DDP. In our present analysis, however, we have considered the mine vent. In this case, we have used a momentum or jet plume rise with an exit velocity of 30 meters per second. This yields a plume rise of 186 meters when the mean wind speed is 2 meters per second. This plume rise is, like the others, greater than the plume rises calculated for the original DDP.

As the mean wind speed increases, the plume rise from the mine vent will decrease. For example, the plume rise for a mean wind speed of 15 meters per second is 25 meters. This is of little consequence in meeting air quality regulations, however, because the mine vent carries less than 4% of the total sulfur dioxide emitted by the plant for 24-hour averaging times, which is the critical case. Control of the major emitter, i.e. the process unit, will be a more significant factor in achieving air pollution control.

A copy of our calculations is attached.

Very truly yours,

C-b SHALE OIL VENTURE

R. E. Thomason
Manager, Leasehold Development

RET:pmr

cc: R. A. Loucks
R. J. Fernandes
A. M. Ruskin
L. C. Bender
G. E. Fosdick
J. J. Hill

RAW SHALE DISPOSAL PLAN

Substantial amounts of raw shale will be produced as part of the Lessee's mining operation on the Tract. The Lessee has developed a Raw Shale Disposal Plan to describe the proposed activity, review the applicable Lease terms, laws and regulations, and set forth the Lessee's plan for compliance. In addition to the plan set forth here, the Lessee has prepared other plans in the DDP and Modified DDP which discuss special aspects of raw shale disposal. These plans include:

- Air Pollution Control (Section V.A.)
- Water Pollution Control (Section V.B.)
- Protection of Objects of Historic or Scientific Interest and Aesthetic Values (Section V.D.)
- Rock Handling and Disposal (Section III.C.R.)
- Overburden Mangement (Section V.G.)
- Erosion Control and Rehabilitation Plan (Addition to Modified DDP)

1. Summary of Proposed Activities Affecting Raw Shale Disposal

The disposal of raw shale will commence with the shaft-sinking and mine development of the ancillary stage of operation. Material produced during the shaft-sinking period will be hoisted to the surface, loaded into dump trucks and transported to the construction area, where it will be crushed to specification of a construction fill material required for the surface plant site. Material produced during the development of stations, access ways, service areas, and during the initial retort development mining will be transported to the 15-foot diameter shaft, hoisted to the surface, loaded into dump trucks, and transported to selected sites to be used as fill for Cottonwood Gulch and later Sorghum Gulch.

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

Section 11 of the Stipulations requires that the Lessee shall: backfill and/or reclaim excavated material and processed shale and compact it thoroughly; design slope faces of waste piles to insure slope stability; revegetate slope faces and other areas in accordance with the rehabilitation plan; and comply with numerous requirements for the restoration of disturbed land. Certain regulations relating to grading and land restoration are also set forth in 43 CFR, Part 23.

The various considerations in raw shale disposal are discussed in the following sections: a) raw shale properties; b) production quantities and site selection; c) disposal procedures; d) water diversion and control; and e) stabilization and rehabilitation.

a) Raw Shale Properties

Raw shale texture is expected to vary from silt and clay to gravel and larger. In the mine the material, as run from mining and feeder breakers, will be approximately 8 inches or finer. Because of expected segregation from settling during movement on conveyors and trucks, no accurate particle size distribution can be estimated. Also, dust control measures will affect this estimate. A rough estimate of particle size distribution for mine run raw shale is:

Larger than 1/4 inch	62%

Very coarse sand	26%
Coarse to medium sand	6%
Fine sand	3%
Silt and clay	3%

Chemical analyses indicate the following properties:

pH - High but similar to native soils
Saturation percentage - low, typical of sands and gravels
Electrical conductivity - moderate salts present
Sodium - high
Nitrate-nitrogen - low
Ammonia-nitrogen - present, but not enough for satisfactory plant growth
Boron - high
Carbonate and bicarbonate - high
Calcium and magnesium - low
Exchangeable potassium - high
Available phosphorous - low
Fluorine - high

The main problem associated with raw shale is the coarse texture and therefore poor water-holding capacity. However, with the planned covering of the disposal pile with 18 inches of plant growth medium; the coarse texture and nutrient deficiencies - existing chemical properties should not greatly affect the reclamation program.

b) Production Quantities and Site Selection

Raw shale produced during mine development will be placed as fill in Cottonwood Gulch. Fill will begin at the south end and proceed to the north. Cottonwood has a capacity of approximately 106,300,000 cubic yards of fill up to an elevation of 6900 feet. This will contain the raw shale produced during the ancillary phase of development and will extend approximately 3.6 years beyond the start of full scale in situ retorting on September 1, 1982.

Sorghum Gulch filled to 6900 feet elevation has a capacity for approximately 11.6 years of production allowing for dam water storage and drainage systems.

The combined capacity of both Cottonwood and Sorghum Gulches will accommodate production from the first 20 years of operations. Other minor and major gulches on the Tract, including Stewart and Scandard, have capacity to accommodate an additional 40 years of full production.

Several alternates to the use of Stewart and Scandard Gulches are also available. One is to continue to fill above the general elevation of the site in several localized areas as proposed in the DDP. At the same average land usage of 1,100 acres and 336,000 tons/acre described in the DDP, about 30 years of production of this plant capacity is available. These piles would be from 100 to 200 feet above the surrounding terrain.

Another potential alternate would be to return the shale underground to the voids in the retort panels after the panels are exhausted. It seems reasonable that within the 22-year period before Cottonwood and Sorghum Gulches are filled, detailed techniques for returning this material underground will be developed. The shale would be in a form that could be transported and placed as a slurry using circulating water as a vehicle, most of which could be recovered from each cycle.

Besides the advantage of returning the material underground, this method would reduce the need for much of the revegetation required for surface disposal of shale. It would also eliminate the requirement for continuous water application during revegetation activity.

During commerical operation, mined shale will be transported to the surface through the production shaft. This material will be transferred onto a covered belt conveyor system, moved to selected areas in Cottonwood Gulch and spread over these sites by a conveyor placement system.

Before any fill is started, soils in fill areas will be stripped and saved for later use as a plant-growth medium to facilitate revegetation.

The quantitites of mined-out raw shale on a daily basis will be 41,000 tons vs 66,000 tons of spent shale in the DDP. This reduction will also facilitate placement and revegetation.

Dust-control methods will be applied throughout the handling and placement of the mined-out shale. Since this material is fairly coarse, there will be less demand for initial water than equal quantities of above-ground retort spent shale. The mined-out raw shale will be placed in such a manner that it may be reclaimed for further processing, if economics indicate this to be feasible.

c) Disposal Pile Construction Procedures

1. General

Raw shale is brought to the surface in the course of forming in situ retorts. It is desirable to store or dispose of the shale in a disposal pile configuration that resembles the surrounding landscape.

The proposed above-the-ground raw shale disposal system will consist of the following:

- Raw shale receiving and surge storage
- Raw shale conveying to the land fill areas
- Shale spreading and leveling over the fill
- Auxiliary equipment to control the environmental impact

2. Raw Shale Receiving and Surge Storage

Raw shale from underground is brought to the surface by means of two skip hoists operating inside the production shaft. The above-the-ground

system starts receiving the raw shale discharged by the skips into two surge bins. Shale will be reclaimed from each bin by a 72" wide apron feeder; each feeder in turn feeding onto a 48" wide, 500 feet long belt conveyor. The conveying system peak load is estimated to be 3,500 STPH and the system design capacity is 4,000 STPH. The average load is approximately 2,900 STPH; therefore the conveyors will be only 73% loaded to insure against spillages.

The two 48" belt conveyors run parallel due east and discharge into a single 1,000 S.T. live capacity surface surge bin.

The conveyor system will occupy a strip of land approximately 30 feet wide and will include an adjacent service road. Construction of the road and conveyor will require excavating for the road and building a ground support base for the conveyor. The service road will be used to maintain the conveyor and to remove any spillage which may occur.

3. Raw Shale Conveying To the First Land Fill Area

Cottonwood Gulch

Reclaim from the surface surge bin will be by two 72" apron feeders, feeding onto a single 54" wide, 1,200 feet long belt conveyor, due east, ending at transfer tower No. 1, and discharging through a splitter-gate-controlled bifurcated chute. Transfer tower No. 1 is located on the west side ridge of Cottonwood Gulch.

4. Shale Spreading Over the First Fill Area

Cottonwood Gulch

The bifurcated chute allows discharge onto either of two skid-mounted shiftable belt conveyors, each 54" wide, 3,500 feet long. One conveyor is originally due north, and the other due south along the Cottonwood Gulch west side ridge.

The top soil will be removed from the fill area by mobile scrapers before the start of the filling operation, and stored on the west side of the shiftable conveyors.

Each shiftable conveyor will discharge through its own self-propelled rail-mounted travelling tripper onto a self-propelled portable truss conveyor, spreading the shale along the fill side (east side) of the shiftable belt conveyors.

While the north shiftable conveyor is spreading the shale, the south conveyor is being shifted radially, pivoting around transfer tower No. 1, by means of a side-boom pipe-layer type bulldozer, and alternatively when the south conveyor is spreading, the north conveyor will be shifted. The two conveyors will be gradually "fanning" into the middle of the fill area.

Leveling will be done by wheel-mounted scrapers and bulldozers. The frequency at which the two shiftable belt conveyors will be moved will vary depending on the depth of the valley being filled at each position, but after each shifting, top soil from the heap will be spread over the

filled area to allow for revegetation.

After 8.6 years of operation, the two shiftable conveyors will have "fanned" into the middle of the fill area, and 106,300,00 cubic yards of raw shale will cover Cottonwood Gulch up to an elevation of 6,900 feet, which is below the highest elevation in the area of the gulches.

5. Raw Shale Conveying to the Second Land Fill Area

Sorghum Gulch

After filling Cottonwood Gulch, the bifurcated chute at transfer tower No. 1 will be moved to transfer tower No. 2, which will be installed on the west side ridge of Sorghum Gulch. A new 54" wide belt conveyor will be installed to convey the raw shale from transfer tower No. 1 to transfer tower No. 2. The two 54" shiftable belt conveyors will be reinstalled due north and south from transfer tower No. 2, along the west side of Sorghum Gulch.

6. Shale Spreading Over the Second Fill Area

Sorghum Gulch

Top soil removal, raw shale spreading and leveling, and revegetation will be done in a manner similar to that explained for Cottonwood Gulch.

After 6.2 years of operation, the two shiftable conveyors will have "fanned" into the middle of the fill area, and 76,600,000 cubic yards of raw shale will cover the southern portion of Sorghum Gulch up to an elevation of 6,900 feet.

If the northern portion of Sorghum Gulch is further used as fill area, another 5.4 years of filling operation are available.

7. The spreading of the shale in the land fill areas will be performed in such a way as not to disturb the natural drainage pattern of the area.

8. Auxiliary Equipment to Control Environmental Impact

Dust collection will be provided in the production shaft loadout station. It is expected that the material will have 3% to 5% free moisture (intragranular moisture) which, in normal conditions, should not create dust on streamline conveyor to conveyor continuous transfers. The conveyor transfers will be made in fully covered chutes with loading skirt-boards, and rubber curtains to contain the small amount of dust that may be liberated at the material transfer points.

A dust suppression spray system will be provided at every transfer point, manually controlled to operate only when it is required.

9. After the first 20 years of operation, other methods or fill areas will be required.

Placement of raw shale will require precise timing and control of the placement sequence. The relatively narrow valley bottoms and areas

adjacent to exposed slopes provide limited working spaces. Placement activity cannot be entirely localized in such restricted areas, so it will be spread out to permit adequate equipment working space. In any one year, a maximum of 100 acres will be created for rehabilitation. If necessary to control fugitive dust, half the area will be planted in the spring and the other half in the fall. See table below:

Disposal Pile Surface Areas Created by Year (Acres)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
0	15	20	75	100	100

Usable soil and overburden materials will be removed ahead of filling and stockpiled for reuse in reclamation. This removal will be done as embankment height increases and will proceed concurrently with filling operations. Overburden materials will be removed and placed directly on completed surfaces to minimize stockpiling and multiple handling. Stockpiles will be built upstream of the fill if space permits, but not on the plateau or ridges (Section V: G., Overburden Mangement Plan).

Backfilling the mine with raw or processed shale is a potential method of reducing the amount of shale disposed of on the surface. However, according to present plans, at least initially the raw shale will be placed on the surface of the Tract until the feasibility of surface retorting is further defined.

The configuration of the pile will incorporate guidelines mentioned in the Fish and Wildlife Plan and the Erosion Control and Rehabilitation Plan: 1) slopes will be limited to a 4:1 angle; 2) the raw shale and cover material will be placed and graded to resemble the varied landforms surrounding the dumpsite. Variation in landform and therefore vegetation is an important wildlife goal.

d) Water Diversion and Control

The potential for pollution of surface and subsurface waters from rainfall and snowmelt through runoff, percolation and leaching is recognized and is being studied. Other studies have evaluated: the balance between precipitation, evaporation, runoff and plant usage; the implications of pile saturation and percolation; the potential for leaching various inorganic salts and heavy metals from processed shale; and the effects of freeze-thaw cycles on the surface of the pile. The pollution potential exists because surface runoff could contain suspended solids, concentrations of dissolved solids (primarily the sulfate salts of sodium, potassium, calcium and magnesium) and trace quantities of other elements.

Laboratory and field studies have examined the relative leaching characteristics of the native soil, raw shale and processed shale. From the study of these tests and because of limited water penetration, it is expected that no leachate will be produced except at the edges of the pile where shale thickness is less than five feet. Further leaching tests on raw shale are underway to investigate the leaching potential and to relate this to field conditions.

The horizontal benches on the front slope of the embankment will slope toward the embankment at a 10% slope, leading to downslope drainage flumes which will convey the runoff down and away from the embankment. The benches will contain a sealed invert to convey the water while retarding erosion. The drainage system will be designed for the 100-year flood and will be installed so as to produce minimal damage to the embankment if design flows are exceeded. Drainage flumes will be 3 to 4 feet in width, depending upon the area drained. Larger-size or duplicate flumes will be installed to route runoff from the top of the embankment and surrounding watershed along the interface between the lateral shale and natural surfaces. This will minimize erosion and preclude excessive infiltration at the interface.

The exact location and number of flumes will depend upon the shape and surface area of the embankment face. Spacing will be approximately 400 feet between downslope flumes. Drainage will be toward the outside limits of the embankment, where central flumes will join the outside ones. Transition sections and energy dissipators will be installed as required near the top of the embankment. Small settling basins will be constructed to remove the suspended solids from the main flow to the catchment basin. These will be cleaned periodically as necessary.

Because the emplacement of raw shale will take place in a step-by-step manner, it is envisioned that the revegetation program will also proceed by phases. A further description of the revegetation phases and procedures is given in Section V. K., Erosion Control and Rehabilitation Plan.

e) Stabilization and Rehabilitation

The procedures described in Section V. K. will be utilized throughout the raw shale disposal activities to insure compliance with environmental criteria and controls required by the Lease.

FISH AND WILDLIFE PLAN - OUTLINE

1. INTRODUCTION
2. DESCRIPTION OF LEASE TRACT
3. PROPOSED ACTION
4. ESTIMATED EFFECTS OF ACTION
5. MITIGATION MEASURES
6. SUMMARY

1. INTRODUCTION (AND HISTORY)

2. DESCRIPTION OF LEASE TRACT

A. TOPOGRAPHY

B. VEGETATION

(1) PINYON JUNIPER
(2) CHAIN PINYON JUNIPER
(3) VALLEY SAGEBRUSH
(4) UPLAND SAGEBRUSH

C. FISH AND WILDLIFE (FAUNA)

(1) LARGE MAMMALS
(2) MEDIUM MAMMALS
(3) SMALL MAMMALS
(4) REPTILES AND AMPHIBIANS
(5) AVIFAUNA (BIRDS)
(6) FISH
(7) ARTHROPODS (INSECTS)
(8) ENDANGERED OR THREATENED SPECIES

3. PROPOSED ACTION

- DESCRIPTION OF PROPOSED ACTIVITIES WITH ESTIMATES OF ACREAGES

4. ESTIMATED EFFECTS OF ACTION

5. MITIGATION MEASURES

A. HABITAT CONVERSION

- COOPERATIVE EFFORT WITH D.O.W. AND B.L.M.

B. HABITAT RESTORATION

6. SUMMARY

- WITH STATEMENT OF PUBLIC ACCESS

RMP

FISH AND WILDLIFE PLAN

Developed in cooperation with:

D.O.W. -Department of Wildlife

B.L.M. -Bureau of Land Management

A.O.S.S.O. -Area Oil Shale Supervisors Office

FISH AND WILDLIFE PLAN
(HABITAT MANAGEMENT PLAN)

The C-b Lease Tract was acquired April 1, 1974. The lease grants exclusive right to mine and process oil shale from the approximately 5094 acres contained in the Tract. Lease requirements of data information on the Tract has been previously submitted to the AOSSO. (Quarterly Data Reports and Summary Reports for yearly quarters ending November, 1974 and February, May, August and November, 1975). This habitat management plan will use the information from the Quarterly and Summary reports as the basic baseline environmental data. This plan spells out what habitat losses will occur and mitigation efforts needed either to replace in kind or to improve alternative habitat for selected species of animals. The plan is to be used for planning within the C-b Venture and for coordination with government agencies. This plan is a dynamic document, which will be updated and revised as new management direction and information becomes available. Because this plan was developed in cooperation with the D.O.W., B.L.M. and A.O.S.S.O. Any revisions will be developed among the original cooperators and in coordination with the Regional Piceance Basin Habitat Management Plan, with final approval of the A.O.S.S.O.

1. Description of Lease Tract

A complete description of the existing environment is given in Annual Summary and Trends Report (November, 1974 through October, 1975) of the environmental baseline report. Additional information is contained in the Quarterly and Summary Reports. Pertinent parts are summarized here for continuity of this plan.

A. Topography

Topography has considerable variation in landform. The rounded ridges in the center of the tract are bissected by shallow V-shaped drainages. Two, larger, U-shaped drainages bissect the tract on the east and west edge of the tract. The sides of these drainages are generally steep and rim rocked. The rimrock is the outcropping of the Uinta sandstone formation which overlies (1000-1300 feet) the oil shale (marlstone).

Drainages run generally south to north with an elevation drop from 7,100 to 6,400 feet. Piceance Creek flows east to west, one-half mile north of the tract.

The Roan Plateau cliffs mark the southern boundary of the basin approximately fifteen miles to the south, and serve as the head water for drainages tributary to Piceance Creek.

B. Vegetation (Flora)

1. Pinyon-Juniper Woodlands (P-J)

Pinyon-juniper woodlands are the most common and widespread vegetation type on the lease tract and surrounding area. The pinyon-juniper is classified as mature, with most stands over 100 years old. Most of the woodlands on the tract have poorly developed herb and shrub

layers. Dominant understory shrubs consist primarily of sagebrush, service berry, bitterbrush and mountain mahogany. Herb understory is mainly western wheatgrass and fleabane with Indian rice grass on the drier, shallower soils. (See Table 1 for species composition.)

Productivity of the P-J vegetation type is the lowest of any type on the tract, 240 lbs./acre. (See Table 2.)

2. Chained Pinyon-Juniper

Chained pinyon-juniper appears to be a shrubland with many fallen trees. Since chaining in 1966, the pinyons and junipers have made some recovery (130 pines per acre and 105 junipers per acre). Chaining was mostly restricted to ridges and gentle hillsides. The dominant species include big sagebrush, bitterbrush, and saplings of pinyon pine and Utah juniper. Three perennial grass species are common: Indian ricegrass, squirreltail grass and western wheatgrass. Cheatgrass, goosefoot and tansy mustard are the main annual species.

The chained rangelands constitute ecologically unstable communities. Successional ranges have been in progress since 1966, but may take 100-200 years for the rangeland to return to a woodland vegetation. (See Table 3 for species composition.)

Vegetative production in the chained pinyon-juniper averages 460 pounds per acre (Table 2). Production in the chained rangelands shows the greatest variation of any of the vegetation types and is the second most productive in terms of herbage standing crop.

This type receives the heaviest grazing use due to its high productivity, variation and palatability of the vegetation. Generally deer use the edges, approximately the first 100 yards from the P-J type, but cattle use the entire type.

3. Valley Sagebrush

Valley sagebrush is widely distributed throughout the Piceance Basin, depending on soil salt concentration; the alluvial fans and valleys support big sagebrush (intermediate salt levels), greasewood (Higher salt concentrations) and rabbitbrush on areas which have apparently been disturbed, probably by fire. The stream trenches support narrow bands of lush semi-aquatic vegetation, and the flat floodplains originally supported Great Basin wild rye communities. Remnants of this original pattern of vegetation can still be found along the upper reaches of Piceance Creek near Rio Blanco store. Cheatgrass, western wheatgrass, goosefoot and stickseed are also found in this vegetation type. (See Table 4.)

Productivity ranges from 275-7800 pounds per acre, and is mostly from the shrubs. The lower figure (275) represents herb layer production, and the higher figure represents herb and shrub standing crop. (See Table 2). Highest production was in big sagebrush where there was not only yearly increase in plant weight, but also very high sagebrush densities which characterize this vegetation type.

Most of the grazing on the Valley Sagebrush areas is in the spring, when the cattle are moving to the high country, and in the fall when they are returning. The greasewood sub-type on Piceance Creek receives heavy grazing in the winter. This use is the result of cattle concentrating there to be fed hay rather than palatability of the shrubs.

4. Upland Sagebrush

Upland sagebrush communities occur on broad ridgetops and in clearings within the Pinyon-Juniper woodlands. This community type usually does not develop on steeply sloping sites. Big sagebrush is the dominant species with other shrubs relatively unimportant. Saplings of pinyon pine and juniper commonly occur, prickly pear is scattered. Western wheatgrass, junegrass, long-leaved phlox, false dandelion and mariposa lily are common herbs in this vegetation type (See Table 5).

Total productivity averages 560 pounds per acre in mid-July. Next to the chained rangeland sites, these communities have the greatest herb-layer production; (300 pounds per acre). Shrub production in the upland sagebrush communities was much less than in the bottomland communities (250 pounds per acre vs. 7500 pounds per acre). But, because the Valley Sagebrush type is low in palatability, seasonal (most of the herb layer species are annuals which are green only in May-June); and over grown (dense stands of Sagebrush over six foot tall), the upland sagebrush type produces more useable forage for wildlife and domestic livestock. (See Table 2)

C. Fish and Wildlife (fauna)

Table 6 lists the more abundant mammals found on the tract.

1. Large mammals

Approximately 200 deer have wintered on the lease tract during the last two years. Deer pellet-groups established that as many as 600 deer use the tract for short periods of time, mainly when the deer are moving to summer range and back to winter range. Some deer occupy the tract and surrounding area from approximately October through May, depending on climatic conditions.

Cattle are released to graze in the hay meadows in early spring; as the growing season progresses, the cattle move away from the hay meadows, pass through Tract C-b (May) and summer at higher elevations south of the tract. As winter approaches, the cattle move down from the summer range (October), pass through Tract C-b and utilize the hay meadows extensively. The P-L Ranch runs cattle on the Piceance Mountain allotment. Approximately 590 A.U.M.s can be run on the tract, and additonal federal land (1000 acres) for a month in the spring and fall. Productivity measurements for the herbaceous layer indicate very light grazing rates by cattle on Tract. Also, outside studies have shown that where dual use of summer-early fall range

by cattle and deer occurs, cattle consume grass and grasslike plants in abundance while grasses are insignificant in the diet of mule deer (Locaas 1958; Wilkins 1957; Dasek 1975). In these areas of dual usage, forbs were the most important item in the muledeer diet (Reynolds 1960).

It appears that the present pattern of use precludes large numbers of deer and cattle from occupying Tract C-b simultaneously. However, dual usage of vegetation types does occur for a limited period during March, April and October when both species utilize hay meadows in Piceance and Willow Creek valleys outside the Tract C-b boundary. The meadows and south-facing slopes along Piceance Creek are the most critical and limiting habitat in severe winters for deer. Habitat improvements in these areas will benefit the deer population greatly.

Elk occasionally occur within the boundaries of Tract C-b as evidenced by tracks and fecal pellets. An unknown number of elk are reported to have spent at least part of the winter (February, 1975) within the one-mile surrounding zone. Elk were sometimes observed at higher elevations to the south of the Tract.

There have been no sightings or evidence of black bear, mountain lion or feral horses within the Tract C-b study area.

2. Medium-sized Mammals

Medium-sized mammals identified within the study area include the desert cottontail, coyotes, bobcat, badger, raccoon, striped skunk, porcupine, white-tail jackrabbit, muskrat and beaver. Desert cottontails are ecologically important because they are a major prey species. Marked yearly changes in density probably occur in the Tract areas. Such fluctuations have the potential of influencing the population of bobcats, coyotes, and some raptorial birds. Cottontails are most abundant in the Valley Sagebrush type, and because rimrock is in close association, these two habitat types are of special significance. The rimrock areas are important to bobcats and several species of raptors as den sites, nesting areas and hunting areas. Coyotes are common in the Tract area, and occur in most habitat types. Surveys and field observations indicate an abundance of coyotes in the Tract vicinity.

3. Small Mammals

Small mammals on the Tract are represented by shrews, ground squirrels, chipmunks, gophers, wood rats, mice and moles.

4. Reptiles and Amphibians

Table 7 lists the reptiles and amphibians observed on the Tract. Lizards were studied because of their abundance and presumable importance in the biological system. Other reptiles and amphibians were observed and noted.

5. Avifauna

Birds are very numerous in the area during the summer in all habitat types. A listing of birds occuring on the Tract is listed in Table 8. Birds are most common from May to October. By late November, most summer residents and migratory species had left the Tract region, and more winter residents had appeared. Many of the wintering species fed and rested in loosely organized flocks which appeared to move over large portions of the Tract and to feed in a variety of different habitats. Waterfowl observations were limited mainly to the Oldland Road Pond and the P-L Ranch Pond.

Raptorial birds include the vultures, hawks, eagles, falcons and owls. Red-tailed hawk and American kestrel are the most common raptors. Golden Eagle and American kestrel are permanent residents in the area. Locations of all raptor nests encountered were mapped and rechecked for occupancy. Night road transects were traversed to assess owl activity. Pellets and casts were collected from nesting, roosting and feeding sites used by birds of prey.

6. Fish

Piceance Creek is generally characterized by a meandering stream channel, fluctuating flows, high levels of dissolved solids, high turbidity, silted rock and gravel substrates, and infrequent pool and shelter areas for fish. These factors make much of the habitat unsuitable for large gamefish populations. In the vicinity of the Tract, Piceance Creek supports higher populations of fish than are found in Stewart Creek and Willow Creek. These are primarily mountain sucker, speckled dace and brook trout. A few rainbow trout have been collected in the middle reaches of Piceance Creek. The Tract is crossed on the west by Willow Creek and Middle Stewart on the east; length of these permanent streams on the Tract is less than a quarter of a mile. Neither of these streams had fishing use during the last two years.

7. Arthropods

A list of arthropods, data on seasonal abundance and distribution are reported in quarterly reports.

8. Endangered or Threatened Species

It is possible that the two subspecies of the endangered peregrine falcon (Falco Peregrinus var. Falco Peregrinus var. tundrius) occasionally inhabit the area, but no sightings have been documented to date. The nationally threatened prairie falcon (Falco mexicanus) has been sighted once near the Tract. None of these three species of falcons is believed to nest inside the Tract boundaries. The greater sandhill crane (state endangered) has been observed in the Tract vicinity during migration, but none has been seen during the breeding period. The spotted bat (threatened), the black-footed ferret, Colorado squawfish, humpback chub and pharanagat bonytail (all nationally endangered), and the gray wolf, river otter and

wolverine (state endangered), are species of the general region, but none has been reported in the near vicinity of the Tract. More significantly, the Tract is not good potential habitat for any of these species, and could only be considered fair habitat for the prairie falcon and American peregrine falcon.

2. Proposed Action

A. Description

A complete description of the proposed action is given in Section III of the Modified Detailed Development Plan (February 1977). A summary of those actions that will affect the surface habitat follows:

The development of the commercial modified in-situ facilities is represented on the Commerical Development Schedule, Table 9. The Tract C-b development program will extend from September 1, 1977, starting with site preparation, to September 1982, when the mine and surface facilities will be capable of full-scale production.

Site preparation and preconstruction will begin in September, 1977 and continue while shaft sinking mobilization is underway.

Of the four major shafts, the first to be completed will be a 15-foot diameter shaft 500 feet from the northern property boundary. This shaft will perform a dual service during the development period. First, it will serve as a temporary production shaft until the main 34-foot diameter production shaft becomes available, and later it will serve as a ventilation-escape shaft for the mine. An ancillary facility will be constructed in the vicinity of the 15-foot diameter shaft. This facility will permit the lessee to establish the environmental monitoring procedures, to obtain operating experience for processing a cluster of retorts, and to provide a site for the training of mine and processing personnel. Later this ancillary facility will be incorporated into the full-scale facility systems.

The construction of the ancillary facility will begin in April of 1979. The first retorts will be prepared and ready for processing by May of 1980. During this period the main development and construction of the mine, the oil/gas processing and general facilities on the surface, and development of additional retort clusters will continue. By September, 1982, the first eight retort clusters in the initial panel will be kindled. Over the next 12 months, additional clusters will be brought on line until full design production capacity is reached.

While the shaft-sinking operations are being mobilized, certain site preparation and preconstruction activities will proceed. These will include preparation or extension of service roads, construction of water storage to receive underground water from initial dewatering operations, necessary grading for temporary construction facilities, fencing, etc.

The ancillary surface facilities will be located at three sites (see

Map 1). A total of 14 acres will be required for these sites. When no longer needed, this area will be revegetated in accordance with specific plans outlined in Section V.K. of the DDP.

The ancillary surface facilities will be expanded during the processing of initial retorts in order to process the first retort clusters and will cover approximately 59 acres. At this time, the 34-foot shafts will be completed, and these facilities will be connected with the first modules of the full-scale facilities.

The raw shale produced during the mine development will be transported by a conveyor system to Cottonwood Gulch. The raw shale will be placed as a fill starting from the south end and proceeding north. Sorghum Gulch will be the major raw shale disposal area for commercial development. See Map 2 which shows the location of all facilities from initial construction in 1977 through commercial production.

The disposal of raw shale will have the greatest effect on surface habitat of all proposed developments. It will temporarily destroy approximately 1500 acres of existing habitat. See Table 10 for acres of habitat lost by type and the estimated productivity lost.

A starter dam will be constructed in Sorghum Gulch to provide for impounding water during the early stages of development. Check dams will be built below disposal areas and heavy construction areas to prevent heavy sedimentation of streams. (See Erosion Control Plan in DDP V. K.)

3. Estimated Effects of Action

Deer use on approximately one third of the Tract will be disturbed by construction of surface facilities and the disposal pile. The areas disturbed by construction of the surface facilities are located in one small chained area and in a large block of chained pinyon-juniper. (See Map 2). The presence of the facilities coupled with the constant presence of people may cause deer to use other areas. Baseline data suggests that approximately 40 deer that use the proposed facilities areas may be displaced (26.7 deer-days/acre divided by 216 days equals .123 deer/acre multiplied by 500 estimated acres equals 6.2 deer per year affected. See Annual Summary and Trends Report through October 1975 for more details.

Construction of the dam in Sorghum Gulch will not affect deer to a large degree if construction is done during the summer when the deer are generally at higher elevations. The Cottonwood impoundment and Sorgham Dam (less than 20 acres) will hold water which is expected to be of good enough quality that it can be used by wildlife and domestic stock. However, if water tests indicate poorer water quality than expected, the areas will be enclosed by a wildlife-proof fence.

The main road will impede some east/west deer movement through the pinyon-juniper type north of the tract. The main impact will be through deer hit by vehicles while crossing the road. Indirect consequences of development of the Tract are increased hunting pressure, poaching, trail biking and snowmobiling.

Disposal of raw shale in Sorghum Gulch and Cottonwood Gulch will have the major impact on deer and wildlife in general. The fringe of pinyon-juniper along these drainages serve as travel corridors for deer moving to and from Piceance Creek during migration. It is estimated from the baseline data that approximately 185 deer will be forced to a different ridge during migration (.123 deer/acre multiplied by 1500 acres equals 185). In a severe winter, the disposal site is located near the upper limit of deer winter range.

An estimated 235 A.U.M.s will be lost for livestock use during development. At the current grazing price, this represents a loss of approximately $355.00 to the B.L.M. Most of this loss will be spring-fall grazing when the livestock are moving through the Tract.

The effect of habitat loss on small mammals is drastic for the ones living in the proposed disturbed areas, but marginal overall. The avian population will be disturbed, and some will be displaced. Raptor eyries and principal nest sites are not known to exist close to mine development areas or the disposal area. If substantial changes in mammalian populations occur, changes may also occur in the abundance of certain raptor species. However, the small percentage of habitat to be disturbed relative to the total extent of similar habitats in the region suggests that local reductions in small mammal numbers should not have significant consequences on the habitat of wide-ranging raptorial species. As a result of the increased presence of man, poaching could have an impact on raptors.

4. Mitigation

A. Habitat Conversion

The planned mitigation is based on assumed plant-animal responses and normal weather patterns. If these assumptions change or are found to be different, the mitigation measures may have to be altered to meet the changed conditions. The environmental monitoring plan describes methods to be used to verify success of mitigation. At this time, the following is our planned course of action.

The main thrust for mitigative measures will be to provide alternative habitat for wildlife displaced by the activities of Tract C-b by increased production of off-tract areas to the north of the Tract across Piceance Creek. These south-facing slopes are extremely important to wintering mule deer, and they lie within a known deer concentration area. Habitat improvements outlined in the Piceance Creek H.M.P. will also be of mitigative value. These are: Piceance Creek Willow Planting, 1/2 mile stream for trout; Stewart Brush Beating and Seeding, 75 acres for elk, deer and cattle. The priority given these projects are low for the Piceance Basin, but with development of Tract C-b, these projects would have high priority. Funding these projects, or direct involvement in carrying them out are planned. As with improvements to the north of the Tract, H.M.P. Projects will have to be studied in cooperation with the B.L.M., D.O.W., A.O.S.S.O. and the lessee for ranking as to priority and amount necessary for mitigation. When the B.L.M. completes the Piceance Mountain Management Plan, Tract C-b can provide more detailed information. Cooperative management plans will compliment each other.

Habitat improvements for the area north of the Tract will be those which various governmental agencies recommend as important. Potential chained areas will be broken into small irregular blocks of 40 acres or less to simulate natural parks. Habitat improvements will be goal oriented toward increased browse for deer and forage for livestock to the extent that at least the estimated loss of habitat for 150 deer and 235 A.U.M.s cattle are mitigated. Critical early spring deer habitat near Piceance Creek and south-facing slopes above Piceance Creek are recognized as highly important planning areas.

A small dam in Scandard and one in West Stewart are planned to provide early summer and fall water for wildlife and domestic stock. Quantities of water for impoundment are not expected to be large enough for use as permanent water impoundments.

An alternative to the areas north of the Tract are approximately 1500 acres of pinyon-juniper suitable for chaining between Willow Creek and Jimmy Gulch. Also, it may be necessary to fertilize chained areas around the Tract to increase forage production and palatability. Fertilization may be a rapid method to improve habitat, where chaining and spraying return benefits over a longer term.

Alternatives to sagebrush modification projects listed from the Piceance Creek H.M.P. are on Tract areas in Scandard and West Stewart. Also larger areas are found south of the Tract.

Mitigative measures will be scheduled to produce the mitigative benefit in coordination with development of the Tract. Most of the mitigative measures will be accomplished in the first five years of the project.

Reduction in cattle A.U.M.s may be mitigated to some degree by Sagebrush modification, but it would be desirable to improve the habitat of the drainages north of the Tract. A large sagebrush greaswood flat exists on Piceance Creek north of the Tract, which is suitable for improvement. The flat is on deeded land. Agreement will have to be reached with the land owners. The area should be cleared of brush and seeded to a highly productive wheatgrass. If no water was available, a dry land pasture would be much more productive than the existing vegetation. The early green feed will also benefit the deer.

In chained areas, the debris left will provide cover for small mammals. Small mammals preferring pinyon-juniper will be reduced at the expense of those preferring grass and brush types. Rabbits will benefit by the chaining and sagebrush modification. Scattered small islands of pinyon-juniper will be left in chained areas to reduce the impact on birds preferring tree types for nesting.

B. Habitat Restoration

The Erosion Control and Revegetation Plan discusses contouring and revegetation of the new shale pile and other disturbed areas. This plan will address itself solely with the type of vegetation desired on the raw shale pile. It is not desirable to plant the entire raw

shale pile with the same vegetation mixture. The purpose is to create different vegetative types and thus maximize both vegetative production and edge effect.

Vegetation type will be planned for as follows: The south slopes will be planned for a grassland type using adapted native and introduced species. This will provide the early green feed that is heavily used by deer.

West Slopes will be revegetated with a mixture of grasses and shrub types that are adapted to the site. Saltbrush species and other more drought-tolerant shrubs will be emphasized. The north and east slopes will emphasize the more desirable shrubs such as bitterbrush and mountain mahogany which will provide winter feed of good quality.

The level top will emphasize cool season grasses and desirable shrubs. The emphasis will vary depending whether the aspect is northerly or southerly.

Tree species such as pinyon-juniper will be planted over the whole area in general in such a manner that the other vegetation types form pockets within the P-J type. The purpose is to provide travel lanes for wildlife moving between types. This will mean fingers of P-J running over the raw shale pile.

These fingers should be 100-200' minimum width. The idea is to have them dense enough that vision is blocked when viewed from the side. It it is possible to see clear through the finger, it will not provide enough cover to be used by wildlife for travel lanes.

Erosion control dams will be left as water impoundments for wildlife use.

If deer-car collisions become a problem, a cooperative venture will be started with the Division of Wildlife. The use of deer fencing, underpasses, and other feasible methods will be considered. The exact method or methods used to solve the deer-car collision problem will be determined at that time.

C. Public Access

The public will be allowed unrestricted access on the Tract with the exception of production areas. Access across Piceance Creek will be determined by the owner of that right-of-way. All surface production facilities will be fenced and access restricted. Areas where machinery is operating on the disposal pile will also be restricted. No vehicle traffic will be allowed on the ore disposal pile where revegetation is underway. Company personnel will have to comply with company, State and Federal wildlife regulations. Notice will be posted of all applicable laws and regulations governing hunting, fishing and trapping. Also harassment of wildlife, excessive land disturbance or, in general, actions which detrimentally effect the environment will be policed carefully.

5. Summary

This plan was devised as a cooperative venture among the A.O.S.S.O., B.L.M., D.O.W., and landowners affected. It is designed to supplement their plans while at the same time, reducing the impact on the Tract habitat and fauna. After completion of each phase of the project, target animal response will be monitored to insure the desired results are obtained. If the desired result is not obtained, we will, in cooperation with the other agencies, attempt to determine the cause and amend the plan to incorporate the changed situation and goals. If unexpected circumstances or changes arise, the A.O.S.S.O. will be notified for approval of any changes in the original plans 60 days prior to action on the matter.

Table 1

PINYON-JUNIPER TYPE

SPECIES		PERCENT FREQUENCY
Trees (Saplings)		
Juniperus osteosperma	Utah juniper	2
Pinus edulis	Pinyon pine	6
Shrubs		
Amelanchier alnifolia	Serviceberry	2
Artemisia tridentata	Big sagebrush	4
Chrysothamnus nauseosus	Rubber rabbitbrush	2
Herbs		
Agoseris glauca	False dandelion	44
Agropyron smithii	Western wheatgrass	74
Antennaria rosea	Pussy toes	44
Arabis holboellii	Rock cress	30
Astragalus purshii	Pursh-locoweed	2
Astragalus kentrophyta	Kentrophyta milk vetch	34
Bromus tectorum	Cheatgrass	8
Calochortus nuttallii	Sego lily	12
Carex pensylvanica	Sedge	34
Chenopodium album	Goosefoot	22
Colliusia paruifbra	Blue eyed mary	10
Collomia umbellata	Phlox	36
Cymopterus montanus	Cymopterus	20
Descurainia pinnata	Tansy mustard	8
Erigeron sp.	Fleabane daisy	48
Festuca brachyphylla	Sheep fescue	52
Koelena glacilis	Junegrass	43
Lappula redowskii	Stick seed	8
Lomatium orientale	Wild parsley	8
Oryzopsis hymenoides	Indian rice grass	8
Phlox hoodii	Moss phlox	52
Phlox longifolia	Long leafed phlox	66
Poa fendleriana	Mutton grass	20
Sphaeralcea coccinea	Copper mallow	20
Stephanomeria tenuifolia	Wire lettuce	14
Stipa comata	Needlegrass	34

Table 2

TRACT VEGETATION PRODUCTIVITY

Vegetation Type	Condition	Acres	Herb Production lbs/acre	Acre/AUM	Estimated AUM
Pinyon Juniper	poor	1965	240	5	393
Chained Pinyon Juniper	good	2192	460	3	731
Upland Sagebrush	good	553	500	2.6	213
Valley Sagebrush	poor	390	275	4.7	83
				TOTAL	1420 A.U.M.

Table 3

CHAINED PINYON-JUNIPER TYPE

SPECIES		RELATIVE FREQUENCY
Trees (sapling)		
Juniperus osteosperma	Utah juniper	0
Pinus edulis	Pinyon pine	2
Shrubs		
Amelanchier alnifolia	Serviceberry	4
Artemisia tridentata	Big sagebrush	8
Chrysothamnus nauseosus	Rubber rabbitbrush	10
Gutierrezia sarothrae	Snakeweed	12
Herbs		
Agoseris glauca	False dandelion	6
Agropyron desertorum	Crested wheatgrass	36
Agropyron smithii	Western wheatgrass	18
Antennaria rosea	Pussy toes	8
Arabis holboellii	Rock cress	20
Bromus tectorum	Cheat grass	88
Carex pensylvanica	Sedge	18
Chenopodium album	Goosefoot	84
Collinsia paruiflora	Blue eyed mary	10
Cryptantha sp.	Little cryptantha	12
Descurainia pinnata	Tansy mustard	24
Erigeron sp.	Showy fleabane daisy	20
Festuca brachyphylla	Sheep fescue	6
Gayophytum ramocissiumum	Groundsmoke	8
Haplopappus nuttallii	Goldenweed	8
Koeleria gracilis	June grass	20
Lappula redowskii	Stickseed	24
Microsteris micrantha	Microsteris	8
Oryzopsis lymenoides	Indian rice grass	38
Phlox hoodii	Moss phlox	16
Poa sp.	Mutton grass	32
Sitanion longifolium	Squirreltail	40
Stipa comata	Needle grass	8
Taraxacum officinale	Common dandelion	12

Table 4

BOTTOMLAND SAGEBRUSH

SPECIES

Shrubs

Artemisia tridentata	Big sagebrush	54
Chrysothamnus nauseosus	Rubber rabbitbrush	5
Sarcobatas vermiculatus	Greasewood	15
Symphoricarpos orephilus	Snowberry	2

Herbs

Agropyron smithii	Western wheatgrass	70
Agropyron trachycaulum	Slender wheatgrass	10
Androsace septentrionalis	Rock primrose	5
Artemisia ludouiciana	Prairie sage	65
Bouteloua gracilis	Blue grama	20
Bromus tectorum	Cheatgrass	100
Chenopodium sp.	Goosefoot	55
Descurainia pinnata	Tansy mustard	15
Lappula redowskii	Stickseed	40
Lepidium montanum	Mountain Peppergrass	40
Oryzopsis hymenoides	Indian rice grass	5
Poa sp.	Bluegrass	25
Salsola kali	Tumbleweed	5
Sphaeralcea coccinea	Copper mallow	25
Sporobolus cryptandrus	Sand dropseed	40
Stipa comata	Needle-grass	80

Table 5

UPLAND SAGEBRUSH

SPECIES		PERCENT FREQUENCY
Shrubs		
Amelanchier alnifolia	Serviceberry	5
Artemisia tridentata	Sagebrush	85
Chrysothamnus Viscideiflorus	Douglas rabbitbrush	60
Opuntia polyacantha	Starvation cactus	10
Symphoricarpos oreophilus	Snowberry	5
Herbs		
Agoseris glauca	False dandelion	20
Agropyron smithii	Western Wheatgrass	100
Allium acuminatum	Wild onion	15
Arabis holboellii	Rock cress	20
Astragolus pectinatus	Narrowleaf poison vetch	10
A. purshii	Pursh-locoweed	15
A. scopulorum	milk vetch	30
Balsamorhiza sagittata	Arrowleaf balsam root	15
Calochortus nuttallii	Sego lily	35
Carex pensylvanica	sedge	45
Castilleja chromosa	Indian paintbrush	55
Chenopodium album	Goosefoot	25
Collinsia paruiflora	Blue eyed mary	85
Collinsia linearis	Blue eyed mary	40
Comandra umbellata	Bastard toadflax	30
Crepis acuminatus	Hawksbeard	80
Eriogonum umbellatum	Sulphur flowered buckwheat	
Festuca brachyphylla	Sheep festuca	75
Hedysarum boreale	Northern sweet broom	10
Koeleria graeilis	Junegrass	100
Lomatium grayi	Gray's lomatium	30
Lupinus argenteus	Lupine	25
Microsteris micrantha	Microsteris	90
Phlox longifolia	Long leaf phlox	100
Physaria floribunda	Twin pod	75
Polygonum sawatchense	Knotweed	95
Sphaeralcea coccinea	Copper mallow	40
Stipa comata	Needle-grass	65
Trifolium gymnocarpon	Clover	95

Table 6

MAMMALS

Scientific Name	Common Name
Canis latrans	Coyote
Citellus lateralis	Golden-mantled ground squirrel
Cittelus richardsonii	Richardson's ground squirrel
Erethizon dorsatum	Porcupine
Eutamias minimus	Least chipmunk
Eutamias quadrivittatus	Colorado chipmunk
Eutamias umbrinus	Uinta chipmunk
Lagurus crutatus	Sagebrush vole
Lepus townsendii	White-tailed jack rabbit
Lynx rufus	Bobcat
Mephitis mephitis	Striped skunk
Microtus montanus	Montana vole
Microtus pennsylvanicus	Meadow vole
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Neotoma cinerea	Bush-tailed wood rat
Odocoileus hemionus	Mule deer
Ondatra zibethicus	Muskrat
Perognathus apache	Apache pocket mouse
Peromyscus maniculatus	Deer mouse
Peromyscus truei	Pinyon mouse
Procyon lotor	Raccoon
Sorex cinerea	Masked shrew
Sorex vagrans	Vagrant shrew
Sylvilagus audubonii	Desert cottontail
Thomonys talpoides	Northern pocket gopher
Zapus princeps	Western jumping mouse

Table 7

REPTILES AND AMPHIBIANS

Scientific Name	Common Name
AMBYSTOMIDAE	
Ambystoma tigrinum utahensis	Utah tiger salamander
RANIDAE	
Rana pipiens	Leopard frog
IGUANIDAE	
Phrynosoma douglassi	Short-horned lizard
Sceloporus graciosus	Sagebrush lizard
Sceloporus undulatus	Eastern fence lizard
Urosaurus ornatus	Tree lizard
COLUBRIDAE	
Thamnophis elegans	Western terrestrial garter snake

Table 8

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
ANSERIFORMES					
ANATIDAE					
Anas platyrhynchos	Mallard	X	X	X	X
Anas strepera	Gadwall	X	X		
Anas acuta	Pintail	X		X	
Anas crecca	Green-winged teal	X	X	X	X
Anas discors	Blue-winged teal	X			X
Anas americana	American wigeon	X	X	X	
Anas clypeata	Northern shoveler	X			
Anas cyanoptera	Cinnamon teal			X	X
Aix sponsa	Wood duck			X	
Bucephala clangula	Common goldeneye		X	X	
Bucephala islandica	Barrow's goldeneye		X		
Bucephala albeola	Bufflehead		X		
Mergus serrator	Red-breasted merganser		X		
FALCONIFORMES					
CATHARTIDAE					
Cathartes aura	Turkey vulture	X		X	X
ACCIPITRIDAE					
Accipiter gentilis	Goshawk				X
Accipiter cooperii	Cooper's hawk	X			X
Circus cyaneus	Marsh hawk	X			
Buteo lagopus	Rough-legged hawk	X	X	X	
Buteo jamaicensis	Red-tailed hawk	X		X	X
Aquila chrysaetos	Golden eagle	X	X	X	X
Haliaeetus leucocephalus	Bald eagle			X	

Table 8 (2)

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
FALCONIFORMES (Cont.)					
FALCONIDAE					
Falco mexicanus	Prairie falcon	X	X		
Falco sparverius	American kestrel	X	X	X	X
GALLIFORMES					
TETRAONIDAE					
Centrocercus urophasianus	Sage grouse	X			
GRUIFORMES					
GRUIDAE					
Grus canadensis	Sandhill crane	X			
RALLIDAE					
Fulica americana	American coot	X			X
CHARADRIFORMES					
CHARADRIIDAE					
Charadrius vociferus	Killdeer			X	
SCOLOPACIDAE					
Capella gallinago	Common snipe	X	X	X	X
Actitis macularia	Spotted sandpiper			X	X
Tringa solitaria	Solitary sandpiper	X			X
Tringa flavipes	Lesser yellowlegs	X			
RECURVIROSTRIDAE					
Recurvirostra americana	American avocet				X

Table 8 (3)

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	Winter	Spring	Summer
CHARADRIFORMES (Cont.)					
PHALAROPODIDAE					
Steganopus tricolor	Wilson's phalarope				x
COLUMBIFORMES					
COLUMBIDAE					
Zenaidura macroura	Mourning dove	x		x	x
STRIGIFORMES					
TYTONIDAE					
Tyto alba	Barn owl	x			
STRIGIDAE					
Otus asio	Screech owl	x			x
Bubo virginianus	Great horned owl	x	x	x	x
Asio otus	Long-eared owl	x			
Nyctea scandiaca	Snowy owl		x		
Aegolius acadicus	Saw-whet owl				x
CAPRIMULGIFORMES					
CAPRIMULGIDAE					
Phalaenoptilus nuttalli	Poor-will				x
Chordeiles minor	Common nighthawk	x			x
APODIFORMES					
APODIDAE					
Aeronautes saxatalis	White-throated swift				x
TROCHILIDAE					
Selasphorus platycercus	Broad-tailed hummingbird				x

Table 8 (4)

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
CORACIIFORMES					
ALCEDINIDAE					
Megaceryle alcyon	Belted kingfisher	X		X	
PICIFORMES					
PICIDAE					
Colaptes auratus	Common flicker	X	X	X	X
Sphyrapicus thyroideus	Williamson's sapsucker				X
Dendrocopos villosus	Hairy woodpecker	X			
Dendrocopos pubescens	Downy woodpecker	X	X		
PASSERIFORMES					
TYRANNIDAE					
Myiarchus cinerascens	Ash-throated flycatcher				X
Sayornis saya	Say's phoebe	X		X	X
Epidonax wrightii	Gray flycatcher				X
Epidonax difficilis	Western flycatcher	X			
Contopus sordidulus	Western wood pewee			X	X
Nuttallornis borealis	Olive-sided flycatcher				X
ALAUDIDAE					
Alauda arvensis	Horned lark	X	X		X
HIRUNDINIDAE					
Hirundo rustica	Barn swallow	X			X
Petrochelidon pyrrhonota	Cliff swallow	X			X
Tachycineta thalassina	Violet-green swallow	X			X
Iridoprocne bicolor	Tree swallow				X
Stelgidopteryx ruficollis	Rough-winged swallow				X

Table 8

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
CORVIDAE					
Cyanocitta stelleri	Steller's jay	X	X		
Aphelocoma coerulescens	Scrub jay	X		X	X
Gymnorhinus cyanocephalus	Pinyon jay	X	X	X	
Pica pica	Black-billed magpie	X	X	X	X
Nucifraga columbiana	Clark's nutcracker	X	X	X	X
Corvus corax	Common raven	X	X	X	X
Corvus brachyrhynchos	Common crow	X			
PARIDAE					
Parus atricapillus	Black-capped chickadee	X	X		
Parus gambeli	Mountain chickadee	X	X	X	X
Parus inornatus	Plain titmouse			X	
SITTIDAE					
Sitta corolinensis	White-breasted nuthatch	X	X		
Sitta canadensis	Red-breasted nuthatch	X	X		
TROGLODYTIDAE					
Troglodytes aedon	House wren	X			X
Salpinctes obsoletus	Rockwren	X			X
Catherpes mexicanus	Canyon wren	X		X	
MIMIDAE					
Sporeoscoptes montanus	Sage thrasher	X			
TURDIDAE					
Turdus migratorius	Robin	X	X	X	X
Myadestes townsendii	Townsend's solitaire	X	X		X
Hylocichla guttata	Hermit thrush				X
Sialia currucoides	Mountain bluebird	X		X	X

Table [illegible].)

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
SYLVIIDAE					
Polioptila caerules	Blue-gray gnatcatcher	X			X
Regulus calendula	Ruby-crowned kinglet	X			
LANIIDAE					
Lanius excubitor	Northern shrike	X	X	X	
Lanius ludovicianus	Loggerhead shrike			X	
STURNIDAE					
Sturnus vulgaris	Starling	X		X	
VIREONIDAE					
Vireo solitarius	Solitary vireo	X			X
Vireo olivaceus	Red-eyed vireo				X
Vireo gilvus	Warbling vireo				X
PARULIDAE					
Vermivora ruficapilla	Orange-crowned warbler				X
Vermivora virginiae	Virginia's warbler				X
Dendroica petechia	Yellow warbler				X
Dendroica coronata	Yellow-rumped warbler	X			X
Dendroica nigrescens	Black-throated warbler	X			X
Dendroica townsendi	Townsend's warbler	X			
Geothlypis trichas	Common yellowthroat				X
Oporornis tolmiei	MacGillvray's warbler				X
Wilsonia pusilla	Wilson's warbler				X

Table 8 (7)

SPECIES OF BIRDS OBSERVED ON TRACT C-b

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
ICTERIDAE					
Dolichonyx oryzivorus	Bobolink				X
Sturnella neglecta	Western meadowlark	X		X	X
Xanthocephalus xanthocephalus	Yellow-headed blackbird	X			
Agelaius phoeniceus	Red-winged blackbird	X		X	X
Euphagus cyanocephalus	Brewer's blackbird	X			X
Molothrus ater	Brown-headed cowbird				X
THRAUPIDAE					
Piranga ludoviciana	Western tanager				X
FRINGILLIDAE					
Pheucticus melanocephalus	Black-headed grosbeak				X
Carpodacus mexicanus	House finch	X			X
Leucosticte tephrocotis	Gray-crowned rosyfinch		X		
Leucosticte atrata	Black rosy finch		X		
Leucosticte austcalis	Brown-capped rosy finch		X		
Spinus pinus	Pine siskin	X			X
Spinus tristis	American goldfinch	X			
Chlorura chlorura	Green-tailed towhee	X			X
Pipilo erythrophthalmus	Rufous-sided towhee	X			X
Passerculus sandwichensis	Savannah sparrow	X			
Calamospiza melanocorys	Lark bunting				X
Pooecetes gramineus	Vesper sparrow	X			X
Amphispiza belli	Sage sparrow				X
Junco hyemalo	Dark-eyed junco		X	X	
Junco caniceps	Gray-headed junco	X	X	X	X
Spizella arborea	Tree sparrow	X	X	X	
Spizella passerina	Chipping sparrow	X			X
Spizella breweri	Brewer's sparrow	X			X
Zonotrichia leucophrys	White-crowned swallow	X			X
Melospiza melodia	Song sparrow	X	X	X	X

Table 9 - Estimated Surface Disturbance by Year Overall (Acres)

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to Year 2005	Total by Activity
Mine Development												
Surface Facilities 12-ft shaft		8										8
Steam Generation		3										3
Gas Treatment		3										3
Cottonwood Gulch												
Mined Rock Fill Area		15	20	75	100	100						310
Impound Pond			4									4
Road Construction												
Tract Access		8	20	25								53
Service		3	5									8
In Situ Gas Treatment Facilities			44	30								74
Mine Production and Service Shaft Area			15	15								30
Sorghum Gulch												
Dam Site			3									3
Reservoir			3	17								20
Shale Storage Area							100	100	100	100	540	940
Total by Year (Accuracy of Estimate ±25%)		40	114	162	100	100	100	100	100	100	540	1,456

Table 10

ESTIMATED VEGETATION TYPES DISTURBED (ACRES)

	Bottomland Sagebrush	Upland Sagebrush	Chained Pinyon-Juniper	Pinyon-Juniper
Mine Development			14	
Cottonwood Gulch				
Mined rock fill area			310	
Impoundment pond				4
Road Construction				
Tract access	11	5	20	30
In-Situ Gas Treatment Facilities		75		
Mine Production		30		
Disposal Area				
Dam site				25
Shale Storage			461	471
Estimated Total by Type	11	110	805	530
			TOTAL ACRES	1456

EROSION CONTROL AND REHABILITATION PLAN - OUTLINE

1. INTRODUCTION
2. EROSION CONTROL METHODS AND APPLICATION
3. SURFACE REHABILITATION PLAN
4. SUMMARY

RMP

1. INTRODUCTION

2. EROSION CONTROL METHODS AND APPLICATION

3. SURFACE REHABILITATION PLAN, INCLUDING DEMONSTRATION TECHNOLOGY FOR REVEGETATION

   A. DESCRIPTION OF DISTURBANCES WITH ESTIMATED ACRES INVOLVED

   B. REVEGETATION OF DISTURBED AREAS OTHER THAN THE RAW SHALE DISPOSAL

      (1) TIMING
      (2) TECHNIQUES AND MATERIALS

   C. REVEGETATION OF RAW SHALE DISPOSAL PILE

      (1) REVEGETATION TIMETABLE
      (2) METHODOLOGY
      (3) ALTERNATIVES

4. SUMMARY — GOALS

RMP

EROSION CONTROL
AND
REHABILITATION PLAN

EROSION CONTROL AND REHABILITATION PLAN

I. General Introduction and Summary

A. Introduction

The development of the Tract will result in the disturbance of approximately 1500 to 2000 acres of vegetation, soil and rock. This plan discusses the areas which will be disturbed; reviews the applicable Lease terms for controlling these activities; and details the lessee's plan to comply with the Lease terms and other applicable regulations. Included as an integral part of this plan is a program for surface rehabilitation and a discussion of the work which demonstrates the technology for revegetation of disturbed areas.

In addition to the plan described here, the lessee has prepared other plans which discusss certain aspects of erosion control and surface rehabilitation. The plans are:

- Water Pollution Control
- Overburden Management
- Raw Shale Storage
- Oil and Hazardous Materials Spill Contingency Plan

B. Summary of Development Activity

The Tract C-b development program will extend from September 1, 1977, starting with site preparation to September, 1982, when the mine and surface facilities will be capable of full-scale production. Over the life of the project, approximately 1500 to 2000 acres of land will be disturbed (See Table 1).

While the ancillary facilities are being mobilized, certain site preparation and pre-construction activities will proceed. These will include preparation or extension of service roads, construction of water storage to receive underground water from initial dewatering operations, necessary grading for temporary construction facilities, fencing, etc. Facilities, a storage pond and road construction will disturb approximately 80 acres. Disposal of raw shale will disturb approximately 300 acres.

For the commercial phase of operation, an in-situ gas treatment facility will disturb another 75 acres, and the mine and service areas will require 30 acres. Raw shale storage will disturb an average of 100 acres per year after the forth year (See Table 2 for vegetation types disturbed).

C. Summary of Lease Requirements

Section 11 of the Stipulations provides requirements for rehabilitating and stabilizing disturbed lands. Section 11 (B) of the Stipulations

TABLE 1

Estimated Surface Disturbance by Year Overall (Acres)

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to Year 2005	Total by Activity
Mine Development												
Surface Facilities 12-ft shaft		8										8
Steam Generation		3										3
Gas Treatment		3										3
Cottonwood Gulch												
Mined Rock Fill Area		15	20	75	100	100						310
Impound Pond			4									4
Road Construction												
Tract Access		8	20	25								53
Service		3	5									8
In Situ Gas Treatment Facilities			44	30								74
Mine Production and Service Shaft Area			15	15								30
Sorghum Gulch												
Dam Site			3									3
Reservoir			3	17								20
Shale Storage Area							100	100	100	100	540	940
Total by Year (Accuracy of Estimate ±25%)		40	114	162	100	100	100	100	100	100	540	1,456

Table 2

ESTIMATED VEGETATION TYPES DISTURBED (ACRES)

	Bottomland Sagebrush	Upland Sagebrush	Chained Pinyon-Juniper	Pinyon-Juniper
Mine Development			14	
Cottonwood Gulch				
Mined rock fill area			310	
Impoundment pond				4
Road Construction				
Tract access	11	5	20	30
In-Situ Gas Treatment Facilities		75		
Mine Production		30		
Disposal Area				
Dam site				25
Shale Storage			461	471
Estimated Total by Type	11	110	805	530
			TOTAL ACRES	1456

requires that the lessee submit an Erosion Control and Surface Rehabilitation Plan as part of any exploration or development plan. Sections 11 (C) and (J) of the Stipulations also require the lessee to ultimately leave all disturbed areas in stabilized, revegetated condition, consistent with environmental conditions at the time baseline data was gathered. In addition, Section 11 (L) (3) of the Stipulations requires that the lessee demonstrate at the time of submission of the DDP that revegetation technology is available to enable reestablishment of permanent vegetation of a quality to support fauna in the same kinds and same numbers as existed at the time the baseline data was obtained, or that technology will be developed in ten years. This plan is intended to meet all of these requirements.

This plan addresses all methods of erosion control which may be utilized in connection with the Tract development, including construction procedures, operating procedures and revegetation of disturbed areas. It is divided into a section dealing with all aspects of erosion control other than revegetation, and another section on surface rehabilitation and demonstration of revegetation technology. In addition to this plan, many aspects of the planned development activity which have significant erosion control features are discussed elsewhere in the DDP.

II. Erosion Control Plan

Methodology - same as that described in DDP, Page V181-192

III. Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation

A. Introduction

Revegetation of disturbed areas is both an erosion control technique and a means of enhancing forage, wildlife, aesthetic and other values. This plan contains both the methods to be used in revegetation of disturbed areas, including raw shale, and a demonstration of the technology which is available for revegetation.

B. Demonstrated Technology

Numerous studies have shown that semi arid foothills have moderate to high probability for revegetation success. Examples for foothill zone of the Rocky Mountains with 12-14 inches of precipitation:

"past history of rangeland seeding has shown that satisfactory revegetation can be accomplished if the best methods are practiced." (National Academy of Sciences, Rehabilitation Potential of Western Coal Lands, 1974.)

"Average annual precipitation usually should be more than 9 inches where artificial seeding is part of the restoration program." (Plummer, A.P., Restoring Big Game Range in Utah).

"areas that have more than 16 inches of annual precipitation have the best potentials for rehabilitation; those areas that have less than 12 inches have the poorest potentials." (Rehabilitation Potentials and Limitations of Surface-Mined Land in the Northern Great Plains, Packer, Paul E., 1974).

Revegetation Guidelines For Surface Mined Areas, by C. Wayne Cook, R. M. Hyde and P. L. Sims, puts the rehabilitation problem in perspective. "Moisture is the limiting factor in successful rehabilitation of lands disturbed by mining and exploration for coal, oil shale and uranium in the Western states."

In summary, with the additional water we plan to supply, the rehabilitation potential should be classified as high. Also, with just natural precipitation, there are good local examples of successful revegetation:

(1) A disturbed surface soil plot was seeded in the fall of 1972 and 1973 on the western boundary of Tract C-b by researchers from C.S.U. and funded by Colorado Dept. of Natural Resources. This planting indicates many suitable species for a Tract C-b revegetation program.

(2) Evaluation for successfulness of the 1975 revegetation efforts on drill pads and soil test trenches in and around the disposal and proposed disturbed areas for Tract C-b have been good to excellent.

C. Description of Goals and Activity

It is the intent of the C-b Shale Oil Project to rehabilitate lands disturbed during the development of oil shale resources on the Tract in a manner consistent with good ecological practices, economic feasibility and practical land use considerations. To accomplish these goals, a revegetation plan has been developed to:

- stabilize and control erosion on disturbed surfaces by using proven plant materials
- support animal populations at least as extensive as those presently on the Tract
- coordinate the natural processes of ecosystem recovery which occur independent of man by using the best available management practices.

The guidelines presented in this plan are intended as a general format within which specific procedures can be developed. This format will apply in general to the two types of revegetation which are important on the Tract: 1) the re-establishment of plant cover on sites disturbed during the exploration and development phases of the project; and 2) vegetation of raw shale after the mining and retorting operation begins. The first will be an immediate need; the second is a long-term project.

sentence structure wrong here

Major types of sites requiring revegetation of disturbed soils include

abandoned drill pads, access roads, mine and plant sites, support facilities, diversion systems and other cleared support sites. A detailed description of these activities can be found in Sections II and III of the Modified DDP. The size of areas to be disturbed has been previously described. (See Table 1). The revegetation of these sites will follow conventional techniques. All techniques used will be evaluated to determine their suitability in establishing vegetation for the support of existing animal populations. Aesthetics will also be considered.

This plan addresses the overall approach and strategies selected to meet the criteria stated above. Revegetation activities fall into two major categories: 1) planning and design; and 2) implementation. The planning and design category includes the formulation of planting techniques, development of methods for evaluation of site success, and the integration of baseline data and other pertinent information into initial plans and later program modifications.

The implementation category includes site preparation, planting, maintenance, and the evaluation of site success.

Responsiblity for planning, design and implementation will be shared by the staff and field personnel who design the plan specifics; integrate the plans with other management plans, the baseline studies and current data; and coordinate the activities with the AOSS and the Bureau of Land Management (BLM); and finally, implement and evaluate the Surface Rehabilitation Plan.

D. Revegetation of Disturbed Areas Other than Raw Shale

The rehabilitation of sites disturbed during exploration and development will be initiated before development begins and will continue through the developmental period. Areas disturbed by activities other than those relating to the disposal of mine and development wastes will be rehabilitated by procedures discussed in this portion of the Surface Rehabilitation Plan. This portion of the plan provides for biological erosion control on disturbed sites through the rapid establishment of vegetation. It also allows for the eventual reestablishment of native vegetation through the use of careful selected seed varieties and planting methods. The generalized procedures presented here are meant to act as a basis for the development of more specific plans immediately prior to any specific revegetation activity. Specific planting plans will be developed after a physical evaluation of each site, and will follow the general procedures outlined below, modified as required by any relevant baseline data.

(1) Timing Revegetation of disturbed areas will be controlled generally by the activity schedules outlined in Sections II and III. Once an activity has been completed, a site-specific revegetation plan will be prepared and carried out as promptly as possible. In most cases, the timing of seeding may be critical. Thus limited delays may occur in waiting for the appropriate planting season. In all cases, revegetation will occur within one year of completion of an activity and generally much sooner.

(2) Techniques and Materials Guidelines will be followed in the preparation of the site-specific plans which will be used for each area

requiring revegetation. An example of a planting plan for a disturbed site is shown in Table 3. Tables 4 and 5 and the following discussions present the guideline plans for revegetating disturbed areas on the Tract. They are subject to change as new technology, information and experience become available.

(a) Seed Selection

Seed mixtures will be developed according to topography, normal soil moisture and adjacent vegetation, and will incorporate information regarding previous vegetation. Table 6 lists those species which have been successfully established in various habitats found in the Piceance Creek basin. The listed plant species are available from a number of commercial seed and plant material growers in the Western United States. Among these are three companies in Colorado and others in Utah, Kansas and Idaho. The suggested species for specific vegetation are discussed below.

Agricultural Areas: Pasture and hay lands in the Piceance Creek valley and tributary drainages should be easily revegetated. These sites will be seeded with species such as timothy (Phleum pratense), alfalfa (Medicago sativa) and wheatgrasses (Agropyron intermedium, A. sibiricum and A. trichophorum). Other species such as sweetvetch (Hedysarum boreale) and yellow sweet clover (Melilotus officinalis) would also be suitable for these areas.

Bottomland Sagebrush Community: In order to establish initial ground cover in these communities, several species of wheatgrass (Agropyron sibiricum, A. intermedium, A. smithii, and A. Trichophorum) would be suitable. Other species of grasses and forbs (herbaceous plants which are not grasslike) to be used will include needle and thread (Stipa comata), sweetvetch (Hedysarum boreale), fleabane (Erigeron spp.) mariposa lilly (Calochortus spp.) and scarlet globemallow (Sphaeralcea coccinea). Shrub species will also be considered for use in these sites. Species might include big sagebrush (Artemisia tridentata), rabbitbrush (Chrysothamnus nauseosus) and winterfat (Ceratoides lanata).

Plateau Sagebrush Community: Wheatgrasses will also provide a rapid initial cover on these sites (see above, bottomland sagebrush community). Additional grass species, including June grass (Koeleria gracilis), Indian ricegrass (Oryzopsis hymenoides) and needle and thread (Stipa comata) would be suitable for these sites. Several shrub species will be considered either for initial seeding or as transplants in a follow-up operation. Species would include big sagebrush (Artemisia tridentata) and rabbitbrush (Chrysothamnus nauseous). Forb species which might be included in seed mixtures include mariposa lily (Calochortus spp.), Fremont's penstemon (Penstemon freemontii), scarlet globemallow (Sphaeralcea coccinea), milk vetch (Astragalus spp.) and sweetvetch (Hedysarum boreale).

Chained Pinyon-Juniper Community: Grasses which will be selected for use in seed mixtures on chained sites will include pubescent wheatgrass (Agropyron trichophorum), intermediate wheatgrass (A. intermedium), Indian ricegrass (Oryzopsis hymenoides), June grass (Koeleria gracilis),

western wheatgrass (Agropyron smithii), and slender wheatgrass (A. trachycaulum). Forb species would include Freemont's penstemon (Penstemon freemontii), sweetvetch (Hedysarum boreale), and milk vetch (Astragalus spp.).

Bunchgrass Community: Revegetation of these dry sites will be difficult because of low moisture and relatively unstable soil. The most suitable grasses are Indian ricegrass (Oryzopsis hymenoides), bluebunch wheatgrass (Agropyron spicatum), western wheatgrass (A. smithii), and needle and thread (Stipa comata). Two low-growing sage species suitable for these sites are sagewort (Artemesisa ludoviciana) and pasture sage (A. frigida). Forbs such as sulphur flower (Eriogonum umbellatum) would do well if "set out" during follow-up activities.

Pinyon-Juniper Community: The understory vegetation in these woodlands is variable. On those sites where the understory is poorly developed it will be best to either seed or transplant the tree species pinyon pine (Pinus edulis) and juniper (Juniperus osteomosperma) and/or (J. scopulorum). If this is prohibitive, some improvement of the site to prepare it for natural tree seed invasion might be provided by maintenance, fertilization of sites and mulching with slash material. Grass species which can be used on these sites for initial vegetation cover would include wheatgrasses (Agrophyron smithii, A. intermedium, A. trichophorum), Indian ricegrass (Oryzopsis hymenoides) and June grass (Koelerai gracilis). Shrub species for these sites for initial vegetation cover would include mountain mahogany (Cercocarpus montanus), serviceberry (Amelanchier alnifolia), snowberry (Symphoricarpos oreophilus) and bitterbrush (Purshia tridentata). Pinyon-juniper sites with well developed understory vegetation adjacent to them should be seeded with the grass and shrub species listed above.

Mixed Mountain Shrub Community: Mixed mountain shrub stands are located on moist soils and should not be difficult to revegetate. They will, however, require a relatively long period of time for reestablishment of shrubby vegetation, and should be planted with shrub seed and/or transplants. Grasses suitable for initial cover include western wheatgrass (Agropyron smithii), intermediate wheatgrass (A. intermedium), pubescent wheatgrass (A. tricophorum) bluegrasses (Poa pratensis and P. ampula) and Indian ricegrass (Oryzopsis hymenoides). Shrubs should include Gambel's oak (Quercus gambeli), mountain mahogany (Cercocarpus montanus), bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus) and serviceberry (Amelanchier alnifolia). Forbs such as virgin's bower (Clematis spp.) might also be used.

(b) Fertilizer

Restoration of vegetation is more easily and rapidly achieved by increasing soil fertility. Soil sampling to determine fertility will help define fertilization needs (Section XII on Soil Productivity).

Fertilizer applications should be well timed. Available nitrogen

in nitrate form should be applied in the spring. Fertilization during the early summer following seeding will produce good results. Fertilization can make annual weeds very competitive - so, it has to be used carefully.

(c) Mulch Selection

Acceptable mulching materials include excelsior blanket, jute mesh, wood fiber and native hay or straw. Also, an annual cover crop can be used as a temporary mulch. All types will act to retain soil moisture in an arid climate. Each has disadvantages and advantages of its own: excelsior blanket tends to decrease soil temperature; jute mesh tends to increase soil temperature because of lack of shading. Both are fire retardant and weed free, though jute is not easily applied to rocky terrain. Wood fiber is costly, subject to wind damage, and can cause seeds to become caught above ground. On the other hand, it is easily applied to steep slopes and is fire resistant. Native hay or straw is fire prone, but is the most versatile mulch. It combines the advantages of moisture retention, a balanced heat regime, and an additional source of native seed. Hay and straw, however, often contain a high percentage of weedy annuals which are undesirable because they may compete too strongly with the permanent-successional species. The annual cover crop has the advantages of other mulches, but can produce annual competitive growth. The choice of mulch depends on the characteristics of the individual sites. The suggested types are native hay or straw and excelsior.

(d) Seedbed Preparation

An important feature in vegetation is microclimate. Microclimate effects can be obtained by using small terraces and furrows. These will provide protection from the sun's drying effects, will produce locally moist areas, and will also retard erosion caused by runoff.

(e) Seeding and Mulching Operations

Seeding can be accomplished by the use of a hand seeder, or by hydroseeding or drilling. Drilling seed helps seed germination where soil moisture is deficient. Hand seeding is the most time consuming and laborious method, but has shown good results in a variety of areas. Hydroseeding is a time-saving method which also provides an initial application of water that can help germination. However, the application of water in the wrong season (i.e., early fall), will cause late germination and young plants not capable of surviving the winter. Irrigation of plantings should be done early in the growing season to aid the establishment of seedlings. If hydroseeding and mulching (wood fiber mulch) are to be used together, the seed should be applied first, followed by mulch. If it is desirable to apply both in one operation, the pure live seed amount should be doubled since a certain amount of seed is likely to become hung up in the mulch instead of reaching the soil. Seeding rates will vary between sites (north slopes less seed than south slopes) and with different planting methods. Broadcast seeding rates are

double the drilled rate. Applications of between 10 pounds and 30 pounds per acre (depending on the planting method) should result in good stands.

(f) Planting Time

The best time for planting in the Piceance Creek Basin is late in the growing season, past the period for seed germination (September-November), since this enables the seedlings to become established early in the next growing season when soil moisture is less of a limiting factor. Construction times should be coordinated to coincide with favorable planting times where possible. Spring planting, in April and May, may also be feasible.

(f) Invasions

Several plant species are known to be highly competitive in the Tract area and can be expected to invade and establish themselves in the replanted stands. The strongest of these is cheatgrass (Bromus tectorum). Cheatgrass is a hardy, winter annual known for its ability to compete successfully with native perennials. Though an invader, it also has the rare ability to establish itself permanently in climax vegetation.

Native species also can be expected to invade the plantings. Sagebrush (Artemisia spp.) is known to dominate in disturbed areas, but there is no clear successional pattern here, and changes in the herbaceous understory are just as likely with invaders such as cheatgrass (Bromus tectorum), wheatgrass (Agropyron spp.) and needle and thread (Stipa sp.). Other common invaders are Russian thistle (Salsola kali), snakeweed (Gutierrezia sarothrae), pigweed (Amaranthus albus), peppergrass (Lepidium perforliatum), tansy mustard (Descurainia pinnata), tumble weed (Kochia scoparia), tumble mustard (Sisymbrium altissimum) and goosefoot (Chenopodium album).

(h) Fertility Testing

Excavated materials which are not to be treated as fill will be tested for fertility. Based on these tests, an evaluation will be made for possible use of this material as topsoil like material for revegetation.

(i) Use of Existing Vegetation

All existing vegetation removed during construction will be evaluated for possible reuse. Such uses might include: 1) transplant stock, either by removal of individual plants or removal of sods; and 2) cover material, using stumps, fallen timber and slash, either in whole form or chipped and spread, as mulch. In addition, for aesthetic reasons and to minimize erosion, every effort will be made to preserve existing vegetation.

(j) Evaluation and Followup

Field personnel in charge of the revegetation project will periodically

evaluate species success and plot condition. Evaluation of each site will be made at least once each season after planting. These evaluations will continue until it can be determined that the sites are becoming permanently established.

The most reasonable and practicable way to determine whether or not a given area will support animal populations is to test the available forage on the site by using standard vegetation sampling methods. To determine whether a site is self-perpetuating or becoming self-perpetuating, the evaluation methods will be coupled with vegetation sampling and with information on successional trends gathered during the baseline data collection period. Many years are required for an area of vegetation to complete succession and become dynamically established. The trends toward this dynamic condition, however, may appear early in the sequence of events.

Sites subject to either periodic or unexpected one-time disturbances will be treated to maintain a vegetation cover.

(k) Alternatives to Revegetation

As shown on Figure 4, it becomes difficult to establish vegetation on slopes greater than 2:1. On areas such as these and on areas where the subsoil is extremely rocky or compacted, it might be appropriate to use treatments other than revegetation. The use of rock cover or the construction of retaining walls are alternate methods which will stabilize the surface and prevent erosion. Rock-covered slopes either can be seeded or left unplanted to allow for natural invasion. The preferred slope angle is 4:1, and wherever possible this should be the slope angle constructed.

E. Revegetation of the Raw Shale Disposal Pile

The ultimate goals in establishing a permanent vegetative cover on the raw shale pile are to stabilize embankment slopes and produce a vegetative cover which will support fauna of the same kinds and in at least the same numbers as at the time the baseline data was obtained. In addition, the use of primarily native and naturalized species will lessen the aesthetic impact of the disposal embankment by blending it with the surrounding area.

As noted in the Fish and Wildlife Plan, the vegetation will be a mixture with as much diversity as the site conditions will allow. Trees and shrubs for cover areas will also make up the planned vegetation composition.

(1) Methodology The main problem with growing plants on raw shale is the texture size of the plant growth medium. Water-holding capacity is very low. The mine run raw shale is rock rubble from blasting and mining. Initial vegetation studies have shown promise with less than 2 inch soil cover over raw shale at Logan Wash (one year of data). From this and other studies of soil covers, an 18 inch soil cover at C-b is proposed. Soil Survey and Productivity Assessment (see XII in DDP) by the S.C.S. and in-house consultants indicate the availability of at least 18 inches of plant growth material. The shallowest soil Redcreek-Rentsac complex has an

effective rooting depth of 10 to 20 inches and the deepest Forelle loam has an effective rooting depth of 60 inches.

A demonstration plot using this proposed depth of cover is planned for construction in late 1977. The plot will be built at either Logan Wash or C-b, depending on availability of raw shale. C-b would be the most logical on-site demonstration.

A supplemental irrigation water system will be designed to produce a rapid-germinating cover despite weather extremes. See table below:

Revegetation Water:

Year	New Acres	Cum Acres	Required Acre Foot of Water
2	15	15	15
3	20	35	27.5
4	75	95	85
5	100	175	137.5
6	100	200	150
7	100	200	150
8	100	200	150
9	100	200	150
10	100	200	150

Water Requirement:

1st year	1.0 Ac.Ft.
2nd year	.5 Ac.Ft.

Revegetation water requirement hits its peak acreage in Year 6 with:

100 Ac. @ 1.0 Ac.Ft.)
100 Ac. @ .5 Ac.Ft.) - 150 Ac.Ft.

With 1.5 acre foot of supplemental irrigation water available in the first two years, the reclamation potential should be high if other proper reclamation methods are employed (time of seeding, protection of new growth, species selection).

The revegetation plan will use species native to the Piceance Creek Basin as much as possible. Naturalized species which have proven desirable for revegetation and/or forage will also be used (i.e. intermediate, pubescent and fairway crested wheatgrass, Russian wildrye). See Table 7 for proposed species palatability and suitability. Also Table 8 shows a tentative species list for Sorghum Gulch.

Fertilization will be based on soil tests of the area planned for reclamation. If any of the seventeen nutrients are at deficient levels in the soil, an application of suitable fertilizer will be applied.

(2) Timetable The reclamation program will progress as follows: After the initial grading, shaping, and contouring of the raw shale disposal embankment, fine textured material which are wastes, will be deposited onto the disposal surface. Wastes (fine-textured mineral material) are expected at the end of the conveyor systems, mine sump ponds, impoundment ponds and erosion control ponds. Organic material from chipped vegetation

and the sewage treatment system will be mixed with the plant growth medium as soil tests indicate a need. Then an eighteen inch native soil cover (plant growth medium) will be spread over the surface of the embankment, and an above-ground sprinkler system will be installed. Seeds of the various grasses and forb species which have given good results in the revegetation demonstration plots will be drilled or broadcast, depending on the size of the plot, watered and nurtured until a cover compatible with the surrounding areas is established. Table 7 lists data on the performance and palatability of some of the species used in studies to date. Past studies have indicated that certain mixtures of grass, forbs, shrubs and trees provide the best mixture for revegetation of disturbed soils. Table 8 contains a tentative list of species for the Tract raw shale disposal area.

The revegetation timetable and step-by-step methods to be followed are:

<u>Year 1</u>
- disposal of raw shale and creation of permanent surfaces
- contouring and shaping
- cover with at least 18 inches of native soil
- fertilization of the surface as soil tests indicate, and add organic material, e.g., sewage sludge, sawdust, ground garbage, etc. and soil micro organisms.
- drill the seed into the plant growth medium
- apply mulch
- irrigate with 1 acre-foot of water for germination and establishment during growing season

<u>Year 2</u>
- fertilize lightly (less than 50N) if necessary
- transplant shrubs and trees
- irrigate with .5 acre-foot to assist plant establishment
- remove irrigation system after growing season
- evaluate.

<u>Year 3</u> (Life of project)
- evaluate

It is anticipated that the stability and self-sustaining capabilities of the planned vegetation will be high if a proper mixture of native plants (which have been in the Piceance Creek Basin for hundreds of years and are therefore suited to this area), naturalized species, and exotic species (which have been proven to grow very well on disturbed soils) are established on the raw shale pile.

Vegetative mixtures are preferable to revegetation with a single species. If one species in a mixture does poorly because of an unfavorable site condition or is killed by rodents, insects or disease, one or more of the others may take its place. Another advantage of mixtures is that some species will develop stands quickly to supply forage, while the slower-developing species become established. Mixtures also produce vegetation with more varied, and often higher, food value. Plants will be chosen which best supplement native ranges. A variety of species like those in the proposed species list will also provide shelter as well as food for the fauna of the area.

The construction of the raw shale pile is discussed in Section V. H. The schedule shows that in Years 1 through 5 after start-up, 110 acres would require revegetation. After Year 5, 100 acres would be revegetated

per year. See Table 1 for estimated surface disturbances.

New information obtained from the continuing studies will make it possible to improve methods and to minimize the effort needed to maintain the most suitable vegetation cover. Continued evaluation of the most suitable species and management practices will tend to improve success. Management and monitoring of established vegetation, for example excluding livestock and wildlife from the area being vegetated during the initial establishment phase to reduce stress on the vegetation being established, is also very important.

In the preparation procedures, it will be necessary to remove the native vegetation and usable soil and talus material from the raw shale disposal area in Sorghum Gulch. Native soil and talus will be removed and stockpiled and maintained for later use as a soil cover for the embankment. Stockpiles which are to be stored for periods exceeding one year will be temporarily vegetated as part of the maintenance program. This stockpiling action will conserve a natural resource (soil) which would be buried if not used. Existing vegetation which is not suitable for transplanting onto the embankment surface may be mixed with the native soil and talus being stockpiled for later use in the revegetation program.

The large areas of the Tract which were chained by the BLM contain large scattered amounts of dead sage, pinyon pine and juniper. Additional plant materials also will be knocked down during future clearing operations. Consideration will be given to utilizing that organic material by grinding, chipping, or otherwise cutting it into small pieces for use as a vegetative soil building mulch in revegetation efforts. It should be noted, however, that such use of brush and vegetation destroys a habitat for birds, small mammals and other forms of wildlife.

(3) Alternatives   Alternative to the revegetation program, in addition to the plan described above, are:

- no revegetation program, and, hence, an uncovered raw shale pile
- use of artificial cover
- establishment of agricultural crops

The first alternative, which involves disposing of the raw shale in a disposal embankment without cover, is considered undesirable because of negative effects on the environment (low aesthetic value, and no forage production).

The second alternative, using an artificial cover such as concrete or asphalt to prevent erosion of a disposal embankment, also is considered undesirable because of the poor aesthetics of most of the available materials, both initially and after exposure to the local climate. An artificial cover would be only temporary and would have the additional disadvantage of requiring periodic maintenance or replacement.

The third alternative would be to establish agriculture crops. This type of cover would have the advantages that it could be used by fauna of all kinds and would have a monetary value. But this would require constant care and would result in a permanent habitat loss to some animal species.

Table 3 -- EXAMPLE OF REVEGETATION SITE PLANTING PLAN

SITE DESCRIPTION AND LOCATION Air Quality-Met Tower, Chained Pinyon-Juniper

PLANTING PERIOD Oct. 15 - Nov. 15 SEED APPLICATION broadcast and drill

SEEDBED PREPARATION hand scarification

MULCHING TREATMENT distribute slash

FERTILIZER none

FENCING none REMARKS provide gravelled access to tower and instrument trailer

SPECIES LIST AND RATE

COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Siberian wheatgrass	Agropyron sibiricum		2
Intermediate wheatgrass	Agropyron intermedium	Amur	2
Western wheatgrass	Agropyron smithii	Rosana	2
June grass	Koeleria gracilis		2
Indian ricegrass	Oryzopsis hymenoides		1
Slender wheatgrass	Agropyron trachycaulum		1
Mountain mahogany	Corcocarpus montanus		1/2
Snowberry	Symphoricarpos oreophilus		1/2
Sweetvetch	Hedysarum boreale	Utah	1/2
		TOTAL LBS/ACRE	11½

Table 4 —GUIDELINES FOR SEED MIXTURES ON DISTURBED AREAS

All seed mixtures in lbs./acre

Species	Air Quality Met. Tower, chained pinyon-juniper	A-1, bottomland sagebrush, near main turnoff on Piceance Creek road	A-2, bottomland sagebrush, Pasture	A-3, bottomland sagebrush, in Scandard Gulch	A-4, bottomland sagebrush, head of Scandard Gulch	A-5 bottomland sagebrush, on Piceance Creek at mouth of Cottonwood Gulch	A-6/SG20 bottomland sage-brush, on Piceance Creek road, big cut in hillside next to it	A-7/SG19 bottomland sage-brush, on Piceance Creek at mouth of Sorghum Gulch
Agropyron intermedium (amur) – intermediate wheatgrass	2	3		3	3	2	2	2
Agropyron trichophorum pubescent wheatgrass	2	3		3	3	3	3	3
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	3		3	3	2	2	2
Agropyron trachycaulum slender wheatgrass	1							
Cercocarpus montanus mountain mahogany	1/2							
Elymus cinereus Great Basin wildrye						1	1	1
Hedysarum boreale (Utah) sweetvetch	1/2	1/2		1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2							
Oryzopsis hymenoides Indian ricegrass	1	1		1	1	1	1	1
Purshia tridentata antelope bitterbrush	1/2	1/2		1/2	1/2	1	1	1
Stipa comata needle and thread	1	1		1	1	1/2	1/2	1/2
Symphoricarpus oreophilus snowberry	1/2							
TOTAL	11½	12	0	12	12	11	11	11

Table 4 – (Continued)

All seed mixtures in lbs./acre Species	SG14/A10, bottomland sagebrush, Middle Stewart Gulch	SG15, chained pinyon-juniper, ridge between Scandard and Sorghum Gulches	SG16, chained pinyon-juniper and upland sage, site near Vegetation Plot #3	SG17 pinyon-juniper ridge between West Stewart and Middle Stewart Gulches	SG18, 18a upland sagebrush, head of Sorghum Gulch	SG 19/A 7, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	SG20/A 6, bottomland sagebrush on Piceance Creek road, big cut in hillside next to it	SG21, bottomland sage, Scandard Gulch
Agropyron intermedium (amur) intermediate wheatgrass	2	2	2	2	2	2	2	3
Agropyron sibircum Siberian wheatgrass	3	2	2	2	2	3	3	3
Bromus marginatus mountain brome	2	2	2	2	2	2	2	3
Agropyron smithii (rosana) – western wheatgrass		1	1		1			
Agropyron trachycaulum slender wheatgrass				1				
Cercocarpus montanus mountain mahogany		1/2	1/2		1/2			
Elymus cinereus Great Basin wildrye	1					1	1	
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2		1/2	1/2	1/2	1/2
Koeleria gracilis June grass		2	2	2	2			
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush	1			1/2		1	1	1/2
Stipa comata needle and thread	1/2					1/2	1/2	1
Symphoricarpus oreophilus snowberry		1/2	1/2	1/2	1/2			
TOTAL	11	11½	11½	11	11½	11	11	12

Table 4 –(Continued)

All seed mixtures in lbs./acre Species	SG6, chained pinyon-juniper, ridge west of Sorghum Gulch	SG7/NQ7 chained pinyon-juniper, ridge west of West Stewart Gulch	SG8/A9, bottomland sage-brush, near Oldland Summer Camp	SG9, chained pinyon-juniper, ridge above Scandard Gulch	SG10, upland sage/chained pinyon-juniper, near met. tower	SG11, chained pinyon-juniper, ridge east of Sorghum Gulch	SG12/NQ12, chained pinyon-juniper, ridge east of Sorghum Gulch	SG13, chained pinyon-juniper, lower ridge west of West Stewart Gulch
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	2	2	2	2	2
Agropyron sibircum Siberian wheatgrass	2	2	3	2	2	2	2	2
Bromus marginatus mountain brome				2	2	2	2	2
Agropyron smithii (rosana) – western wheatgrass	2	2	2	1	1	1	1	1
Agropyron trachycaulum slender wheatgrass	1	1						
Cercocarpus montanus mountain mahogany	1/2	1/2		1/2	1/2	1/2	1/2	1/2
Elymus cinereus Great Basin wildrye			1					
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2	2		2	2	2	2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush								
Stipa comata needle and thread			1/2					
Symphoricarpus oreophilus snowberry	1/2	1/2		1/2	1/2	1/2	1/2	1/2
TOTAL	11½	11½	11	11½	11½	11½	11½	11½

Table 4 — (Continued)

All seed mixtures in lbs./acre	NQ4, chained pinyon-juniper, ridge west of Scandard Gulch	NQ7/SG-7 chained pinyon-juniper, ridge west of West Stewart Gulch	NQ12/SG12, chained pinyon-juniper, ridge east of Sorghum Gulch	SG1, bottomland sagebrush, mouth of Scandard Gulch	SG2, chained pinyon-juniper, ridge west of Cottonwood Gulch	SG3, chained pinyon-juniper, ridge east of Sorghum Gulch	SG4, chained pinyon-juniper, ridge between Scandard and Little Scandard Gulches	SG5, chained pinyon-juniper, west of support facility
Species								
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	3	2	2	2	2
Agropyron sibiricum Siberian wheatgrass	2	2	2	3	2	2	2	2
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	2	2	3	2	2	2	2
Agropyron trachycaulum slender wheatgrass	1	1	1		1	1	1	1
Corcocarpus montanus mountain mahogany	1/2	1/2	1/2		1/2	1/2	1/2	1/2
Elymus cinereus Great Basin wildrye								
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2	2	2		2	2	2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush				1/2				
Stipa comata needle and thread				1				
Symphoricarpus oreophilus snowberry	1/2	1/2	1/2		1/2	1/2	1/2	1/2
TOTAL	11½	11½	11½	12	11½	11½	11½	11½

Table 4 —(Continued)

All seed mixtures in lbs./acre Species	A-8. bottomland sagebrush, Lower Stewart Gulch	A-9/SG8. bottomland sage-brush, near Oldland Summer Camp	A-10/SG14. bottomland sage-brush, Middle Stewart Gulch	A-11. bottomland sagebrush, West Stewart, just past turnoff to ridge to met. - tower	A-12. bottomland sagebrush, Upper West Stewart Gulch	A-13. bottomland sagebrush, in wash at head of Sorghum Gulch	Cb2. chained pinyon-juniper ridge east of Cottonwood Gulch	Cb4. chained pinyon-juniper ridge west of West Stewart Gulch
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	2	2	2	2	2
Agropyron trichophorum pubescent wheatgrass	3	3	3	3	3	3	2	2
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	2	2	2	2	2	2	2
Agropyron trachycaulum slender wheatgrass							1	1
Corcocarpus montanus mountain mahogany							1/2	1/2
Elymus cinereus Great Basin wildrye	1	1	1	1	1	1		
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass							2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush	1	1	1	1	1	1		
Stipa comata needle and thread	1/2	1/2	1/2	1/2	1/2	1/2		
Symphoricarpus oreophilus snowberry							1/2	1/2
TOTAL	11	11	11	11	11	11	11½	11½

Table 5 – GUIDELINES FOR REVEGETATION PROCEDURES ON DISTURBED AREAS

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
Air Quality Meteorological Tower, chained pinyon-juniper	Oct. 15 - Nov. 15	broadcast and drill	hand scarification	distribute slash	none	none	provide gravelled access to tower and instrument site
A-1, bottomland sagebrush, near main turnoff on Piceance Creek road	Oct. 15 - Nov. 15	drill	harrow lightly with pipe harrow	none	none	none	favorable site for re-habilitation.
A-2 bottomland sagebrush, pasture	- - - -	- - - -	none, leave as is	- - - -	- - - -	- - - -	vegetation cover has been naturally established
A-3, bottomland sagebrush, in Scandard Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	none	less than 1/10 acre next to road, favorable site
A-4, bottomland sagebrush head of Scandard Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	none	favorable site, western wheat-grass seedlings scattered
A-5, bottomland sagebrush on Piceance Creek at mouth of Cottonwood Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-6/SG-20, bottomland sagebrush, on Piceance Creek road, big cut in hillside next to it	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-7/SG-19, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-8, bottomland sage-brush, lower Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site
A-9/SG-8, bottomland sagebrush, near Oldland Summer Camp	Oct. 15 - Nov. 15	drill	harrow lightly, pit needs cover and litter cleanup	- - - -	- - - -	already in fenced area	area could also be smoothed when pit is covered up
A-10/SG-14, bottomland sagebrush, Middle Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	5 foot cut on west side may re-quire broadcast seeding and mulch excelsior

Table 5 – (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
A-11, bottomland sagebrush West Stewart, just past turnoff to ridge met. - tower	Oct. 15-Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site
A-12, bottomland sagebrush, upper West Stewart Gulch	Oct. 15-Nov. 15	drill	lightly harrow	none	none	3 strand barbwire	favorable site
A-13, bottomland sagebrush in wash at head of Sorghum Gulch	Oct. 15-Nov. 15	drill with some broadcasting	lightly harrow	none	none	none	favorable site, small area about 20 to 50 feet
C-b2, chained pinyon-juniper, ridge east of Cottonwood Gulch	Oct. 15-Nov. 15	drill and broadcast	pad requires minimal roughing; no recontouring is necessary	none	none	none	this site shows voluntary establishment of permanent vegetation
C-b4, chained pinyon-juniper ridge west of Stewart Gulch	Oct. 15-Nov. 15	broadcast and drill	minor ripping and scanfication, recontour	none	none	none	- - - -
NG4, chained pinyon-juniper ridge west of Scandard Gulch	Oct. 15-Nov. 15	drill and broadcast	lightly harrow after recontouring	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	include roadway; water bars needed on roadway site
NQ7/SG-7 chained pinyon-juniper, ridge west of West Stewart Gulch	Oct. 15-Nov. 15	broadcast and drill	rip and cover with available fine material	replace slash	none	none	- - - -
NQ12-SG12, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15-Nov. 15	broadcast and drill	recontour pad; rough and distribute slash	none	none	none	no monitoring access required; some device needed to prevent vehicular traffic
SG1, bottomland sagebrush, mouth of Scandard Gulch	Oct. 15-Nov. 15	drill	(pad has been prepared)	none	none	3 strand barbwire	access for well monitoring required
SG2, chained pinyon-juniper ridge west of Cottonwood Gulch	Oct. 15-Nov. 15	drill and broadcast	recontouring followed by light harrowing	straw or excelsior on cat area	less than 80 lbs. available N.P.K./acre in summer of 1976	none	cut slope requires broadcasting and mulching
SG3, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15-Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -

Table 5 – (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
SG4, chained pinyon-juniper ridge between Scandard and Little Scandard Gulches	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG5, chained pinyon-juniper west of support facility	Oct. 15 - Nov. 15	drill and broadcast	light harrowing following re-contouring	possibly on 6 foot cut	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG6, chained pinyon-juniper ridge west of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	Fine material on edges of bed should be pulled back on pad. Slush should be spread on pad. Minimal roughing with pipe harrow; no contouring.	- - - -	none	none	retain gravel access to monitoring shea
SG7/NQ7, chained pinyon-juniper, ridge west of West Stewart Gulch	Oct. 15 - Nov. 15	broadcast and drill	rip and cover with available fine material	replace slash	none	none	- - - -
SG8/A-9, bottomland sagebrush, near Oldland Summer Camp	Oct. 15 - Nov. 15	drill	harrow lightly. Pit needs covered and litter cleaned up.	- - - -	- - - -	already in fenced-in area	area could also be smoothed when the pit is covered up
SG9, chained pinyon-juniper, ridge above Scandard Gulch	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG10, upland sage/chained pinyon-juniper, near met. tower	Oct. 15 - Nov. 15	broadcast and drill	pad needs minimal roughing and pipe harrow	none	none	none	maintain monitoring access
SG11, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG12/NQ12, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	broadcast and drill	recontour pad; rough and distribute slash	none	none	none	no monitoring access required; some device needed to prevent vehicular traffic
SG13, chained pinyon-juniper lower ridge west of West Stewart Gulch	Oct. 15 - Nov. 15	drill and broadcast	light harrowing; restore contour	none	none	none	- - - -

Table 5 – (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
SG14/A-10, bottomland sagebrush, Middle Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	5 foot cut on west side may require broadcast seeding and mulch excelsior
SG15, chained pinyon-juniper, ridge between Scandard and Sorghum Gulches	Oct. 15 - Nov. 15	broadcast and drill	rip surface recontour pad; pull back toe of pad; replace fine material stockpiled; distribute slash	- - - -	none	none	include several shrub species as transplants as follow-up
SG16, chained pinyon-juniper and upland sage, site near Vegetation Plot #3	Oct. 15 - Nov. 15	drill and broadcast	minimal roughing and pipe harrow; toe of pad should be pulled back	- - - -	none	none	place water bars adjacent to drainings to disperse runoff onto pad; plans include access roadway
SG17, pinyon-juniper, ridge between West Stewart and Middle Stewart Gulches	Oct. 15 - Nov. 15	broadcast	rip surface; replace debris and fine material	none	none	none	allow access through pad/shrub sod; pinyon and juniper set outs as follow-up
SG18a, upland sagebrush, head of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	pad has been ripped and recontoured	none	none	3 strand barbwire	must allow access for monitoring and through pad
SG19/A-7, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
SG20/A-6, bottomland sagebrush, on Piceance Creek road, big cut in hillside next to it	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
SG21, bottomland sagebrush, Scandard Gulch	Oct. 15 - Nov. 15	drill	(seedbed has been roughed) terrace slopes above and below roadway	none	none	3 strand barbwire	fence pad on either side of road; plant shrub species on lower slope terraces

Table 6 - PLANT SPECIES SUITABLE FOR REVEGETATION OF DISTURBED SITES

GRASSES

Agropyron elongatum	(tall wheatgrass)
Agropyron intermedium (amur)	(intermediate wheatgrass)
Agropyron sibiricum	(Siberian wheatgrass)
Agropyron smithii (rosana)	(western wheatgrass)
Agropyron trachycaulum	(slender wheatgrass)
Agropyron trichophorum	(pubescent wheatgrass)
Bromus marginatus	(mountain brome)
Elymus cinereus	(Great Basin wildrye)
Koeleria gracilis	(June grass)
Medicago sativa	(alfalfa)
Oryzopsis hymenoides	(Indian ricegrass)
Phleum pratense	(timothy)
Poa pratensis	(blue grass)
Sporobolus airoides	(alkali sacaton)
Stipa comata	(needle and thread)

FORBS

Artemisia frigida	(pasture sage)
Artemisia ludoviciana	(sagewort)
Astragalus spp.	(milkvetch)
Calochortus nuttallii	(mariposa lily)
Clematis spp.	(virgin's bower)
Erigeron utahensis	(fleabane daisy)
Eriogonum umbellatum	(sulphur flower)
Hedysarum boreale (Utah)	(sweetvetch)
Melilotus officinalis	(yellow sweet clover)
Penstemon freemontii	(Freemont's penstemon)
Sphaeralcea coccinea	(scarlet globemallow)

SHRUBS

Amelanchier alnifolia	(serviceberry)
Artemisia tridentata	(big sagebrush)
Atriplex spp.	(shadscale)
Ceratoides lanata	(winterfat)
Cercocarpus montanus	(mountain mahogany)
Chrysothamnus nauseosus	(rabbitbrush)
Purshia tridentata	(antelope bitterbrush)
Quercus gambelii	(Gambel's oak)
Sarcobatus vermiculatus	(greasewood)
Symphoricarpos oreophilus	(snowberry)

TREES

Juniperus osteosperma	(Utah juniper)
Juniperus scopulorum	(Rocky Mountain juniper)
Pinus edulis	(pinyon pine)

TABLE 7 - PALATABILITY AND SUITABILITY C NT SPECIES USED IN REVEGETATION STUDIES

CLASSIFICATION	SCIENTIFIC NAME	COMMON NAME	PALATABILITY*	SUITABILITY*[1]
Grasses				
Nat**	Agropyron cristatum	fairway wheatgrass	Good	Good
N(PC)**	A. dasystachyum	thickspike wheatgrass	Fair	Good
Ex**	A. elongatum	tall wheatgrass	Poor	Good
N(PC)	A. riparium (sodar)	sodar streambank wheatgrass	Poor	Good
N(PC)	A. smithii (rosana)	western wheatgrass	Fair	Good
Ex	A. trichophorum	pubescent wheatgrass	Fair	Good
Ex	Bromus inermis	smooth brome	Very Good	Good
N(PC)	Elymus cinereus	Great Basin wildrye	Fair	Good
Ex	E. junceus	Russian wildrye	Very Good	Very Good
N(PC)	E. salinus	salina wildrye	Poor	Fair
N**	Festuca ovina	hard fescue	Good	Good
N(PC)	Oryzopsis hymenoides	Indian ricegrass	Fair	Good
N(PC)	Poa ampla	big bluegrass	Good	Good
N(PC)	Sporobolus airoides	alkali sacaton	Fair	Fair
N	S. cryptandrus	sand dropseed	Poor	Fair
N(PC)	Stipa comata	needle-and-thread	Fair	Good
Forbs				
Ex	Astragalus cicer	sicklepod milkvetch	Good	Good
Ex	A. falcatus	chickpea milkvetch	Fair	Good
Ex	Coronilla varia	crownvetch	Good	Fair
N(PC)	Penstemon strictus	Rocky Mountain penstemon	Good	Good
Shrubs				
N(PC)	Amelanchier utahensis	serviceberry	Good	Good
N(PC)	Artemisia tridentata	big sagebrush	Good	Good
N(PC)	A. canescens	fourwing saltbrush	Very Good	Very Good
N(PC)	Cercocarpus montanus	mountain mahogany	Good	Fair
N(PC)	Chrysothamnus nauseosus	rubber rabbitbrush	Fair	Good
Nat	Eleagnus angustifolia	Russian olive	Poor	Good
N	Kochia vestita	desert molly	Good	Fair
N	Purshia glandulosa	desert bitterbrush	Good	Good
N(PC)	Quercus gambelii	Gambel's oak	Fair	Fair
N(PC)	Rhus trilobota	skunkbush	Poor	Good
N	Robinia neomexicana	New Mexico locust	Fair	Good
N(PC)	Symphoricarpos oreophilus	snowberry	Fair	Good

*Based on A.P.Plummer. (1968). **Nat-Naturalized, N(PC)-Native to Piceance Creek, Ex-Exotic, N-Native to Colorado
*[1]Based on observation of E.B. Baker

Table 8 TENTATIVE SPECIES LIST FOR SORGHUM GULCH DISPOSAL AREA

		Species		Drilled Rate (lbs/acre)
Grass:	*	Agropyron cristatum	- crested wheatgrass	2
	*	A. elongatum	- tall wheatgrass	2
	*	A. spicatum var. inerme	- beardless blue bunch wheatgrass	1
	*	A. smithii (rosana)	- western wheatgrass	2
	*	A. intermedium (amur)	- intermediate wheatgrass	1
	*	Bromus marginatus	- mountain brome	1
	*	Elymus cinerus	- Great Basin wildrye	1
	*	E. junceas	- Russian wildrye	1
	*	Festuca ovina	- hard sheep fescue	1
Forbs:	*	Hedysarum boreale (Utah)	- Utah sweetvetch	1/2
	*	Medicago staiva	- alfalfa	1
	*	Melilotus officinalis	- yellow sweetclover	1/2
	*	Penstemon sp.	- penstemon	1/2
Shrubs:	+	Amelanchier spp.	- serviceberry	
	*+	Artemisia tridentata	- big sagebrush	1/2
	*	Atriplex canescens	- four wing salt brush	2
	*	A. confertifolia	- shadscale	1
	*+	Cercocarpus montanus	- mountain mahogany	1/2
	*	Cowania mexicana	- stansberry cliffrose	1/2
	*	Ceratoides lanata	- winterfat	1/2
	*+	Purshia tridentata	- bitterbrush	1/2
	+	Symphoricarpos oreophilus	- snowberry	
Trees:	+	Juniperus osteosperma	- Utah juniper	
	+	J. scopulorum	- Rocky Mountain juniper	
	-	Pinus edulis	- pinyon pine	
				20 1/2 lbs/acre

* Seed

\+ Transplants at approximately 300 per acre placed selectively in areas of suitability and need.

Rate based on: Plummer, A. Perry, Donald R. Christensen, and Stephen B. Monson, 1968. Restoring big game range in Utah. Utah Div. of Fish and Game, Pub. 68-3.

Form 1279–3
(June 1984)

BORROWER'S CAR

DATE LOANED	BORROWER

USDI – ELM